Theory-based promotion of safe water consumption

Thesis

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“Indeed, through self-management of health habits
people reduce major health risks and live healthier
and more productive lives (Bandura, 1997).
If the huge health benefits of these few lifestyle habits
were put into a pill, it would be declared a
spectacular breakthrough in the field of medicine.“
(Albert Bandura, 2001)

Abstract

Almost 800 million people worldwide lack access to improved drinking water sources. As a consequence, water-borne diseases, including chronic illness and increased mortality from geogenic contaminants in groundwater pose severe threats to human health and well-being worldwide. The situation in developing countries is particularly dire, as central water supply is rare, and mitigation therefore more complex. In rural Bangladesh, millions of people are at risk of drinking water with elevated arsenic, despite the fact that many have gained awareness of the health risks, and over 100’000 safe water options have been installed in recent years. It is being increasingly recognized that without people’s compliance, health risks, including water-related risks cannot be mitigated. The social cognition approach proposes that behavior is best explained by an individual’s perceptions of objective reality. Moreover, these determinants are assumed to be modifiable, wherefore interventions targeting the behavioral determinants should increase behavior change effects of standard interventions that are developed without theoretical considerations. This thesis aims at applying this approach to promote safe water consumption.

To identify potential behavioral determinants of safe water consumption, a review of major health behavior theories was conducted first. The identified determinants were compiled to a theoretical framework of potentially influential behavioral determinants. These were linked to behavior change techniques (BCTs) that are assumed to modify the determinants. Three empirical studies were conducted in Bangladesh that assessed arsenic-safe water consumption and the theory-derived behavioral determinants. In Study 1, a large cross-sectional survey was conducted to gain detailed knowledge about current arsenic-safe water consumption in the target population. Structured face-to-face interviews were conducted with 872 households in six districts of Bangladesh. The structured questionnaire assessed people’s acceptance and use of seven currently available arsenic-safe water options. The most influential behavioral determinants of the habitual use of arsenic-safe water options were identified by multiple linear regression analysis. Studies 2 and 3 aimed at developing theory-based interventions to enhance switching to neighboring arsenic-safe shallow wells (Study 2, N = 370), and promote the use of arsenic-safe deep tubewells (Study 3, N = 340). BCTs were developed that targeted the modification of key behavioral determinants that had been identified from baseline surveys. Thereafter, the developed BCTs were added to a standard informational intervention and compared in cluster-randomized trials regarding their effectiveness to increase the effects of the standard

intervention to promote switching to arsenic-safe wells. Moreover, it was determined whether the BCTs would indeed change water consumption by changing the hypothesized behavioral determinants.

Results indicated that overall, one third of the participants of Study 1 did not use the available arsenic-safe water options. Results varied greatly, with piped water supply being the most used option when people had access to it, and rainwater harvesting being the least used. More habitual use of arsenic-safe water options was foremost associated with higher self-efficacy, higher descriptive norms, and higher instrumental attitudes, i.e. when people felt more able to provide as much arsenic-safe water as they needed, when more other people also collected safe water, and when collecting safe water was perceived less time-consuming and effortful. These results were largely confirmed in Studies 2 and 3, but commitment strength emerged as a further important determinant; persons who were more committed to collect arsenic-safe water were more likely to use safe wells. Interventions that targeted increasing commitment strength were developed: reminders, implementation intentions, and public commitment. Confirming most hypotheses, these increased the behavior change effects of the informational intervention by up to 53%, leading to up to 65% well-switching at follow-up. Mediation analyses revealed that the theory-based interventions indeed changed behavior by increasing commitment strength.

The empirical studies demonstrated the usefulness of the social-cognition approach for explaining, predicting, and changing yet another health behavior: safe water consumption. The results of the theory-based interventions provided strong indication that commitment is an important determinant of safe water consumption, and presumably of other behaviors as well. With relevance to health promotion, the increased effects of the theory-based interventions confirm the effectiveness of reminders, implementation intentions, and indicate the importance of more rigorous application of theory in developing and evaluating interventions. Moreover, the here developed BCTs provide promising additions to existing interventions, whereby this research hopes to make a contribution to accelerate the mitigation of arsenic contamination in Bangladesh.

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List of abbreviations

[APA]	American Psychological Association
[BCT]	Behavior change technique
[BDT]	Bangladeshi Taka
[BGS]	British Geological Survey
[CCDB]	Christian Commission for Development in Bangladesh
[CLTS]	Community-Led Total Sanitation
[DPHE]	Department of Public Health Engineering
[ETH]	Eidgenössisch Technische Hochschule
[GoB]	Government of Bangladesh
[HAPA]	Health Action Process Approach
[HBM]	Health Belief Model
[MAP]	Model of Action Phases
[MPMH]	Model of Prospective Memory and Habit Development
[NGO]	Non-governmental organization
[PAPM]	Precaution Adoption Process Model
[PBC]	Perceived behavioral control
[PHAST]	Participatory Hygiene and Sanitation Transformation Series
[PMT]	Protection Motivation Theory
[RANAS]	Risk, Attitude, Norms, Ability, Self-regulation
[SCT]	Social-Cognitive Theory
[SDO]	Society for Disadvantaged Origins
[SODIS]	Solar water disinfection
[SRHI]	Self-Report Habit Index
[TPB]	Theory of Planned Behavior
[TWSDA]	Tribedi Women Social Development Association
[TTI]	Theory of Triadic Influence
[TTM]	Transtheoretical Model of Change
[UNICEF]	United Nations Children's Fund
[VAFWSD]	Voluntary Association for Welfare and Social Development
[VERC]	Village Education Resource Center

[VIF]   Variance inflation factor

[WASH]   Water Sanitation and Hygiene

[WHO]   World Health Organization

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Chapter I

General introduction and overview of this dissertation

1. Theory-based promotion of safe water consumption

The Millennium Development Goal of halving the number of people without access to safe water has been met (United Nations Children's Fund [UNICEF] & World Health Organization [WHO], 2012). From 1990 to 2012, more than two billion people gained access to improved water sources. Despite this enormous achievement, still more than 780 million people (app. 11% of the world's population) do not have access to clean drinking water (UNICEF & WHO, 2012). Most of the people at risk live in middle or low-income countries (UNICEF & WHO, 2012), where 3.8% of deaths in 2004 were attributable to unsafe water, sanitation and hygiene (WASH; WHO, 2009). Diarrhea through microbial contaminated drinking water or lack of improved sanitation and hygiene is a major cause of death, particularly among children under the age of five (WHO, 2009). However, geogenic contamination of groundwater (e.g. through arsenic or fluoride, Amini, Abbaspour et al., 2008, Amini, Müller et al., 2008) poses yet another health risk that is gaining increased attention. In middle or low-income countries, individuals become actors to mitigate water-borne health risks, because water supply is often household based. Decisions need to be made and carried out to purchase or build safe water solutions, and to use and maintain them in the long term. Research has shown, however, that health mitigation behavior, including safe water consumption, often does not follow increased awareness (e.g. Opar et al., 2007; van Geen et al., 2002). Without behavior change, however, any mitigation option will be ineffective (Cairncross & Shordt, 2004). This is being increasingly recognized by WASH professionals. Governmental and non-governmental agencies have started devoting increased effort and resources to promoting health behaviors by increasing people's risk awareness (Khan & Yang, 2012). However, often these interventions show limited behavior change effects (e.g. Caldwell et al., 2006; Opar et al., 2007). As proposed by the social cognition approach, theory-based interventions are likely to yield increased behavior change effects (Conner & Norman, 2005).

Social-cognitive behavior theories assume "that social behavior is best understood as a function of people's perceptions of reality, rather than as a function of an objective description of the stimulus environment" (Conner & Norman, 2005, p. 5). This approach has led to the proposal of various theories (e.g. the Theory of Planned Behavior [TPB], Ajzen, 1991, or more recently, the Health Action Process Approach [HAPA], Schwarzer, 2008) that have identified several important predictors of health behaviors, including attitudes, norms, and self-regulation. The ability of these factors to explain water and health related behaviors has been shown in recent research on solar water disinfection (e.g. Kraemer & Mosler, 2010, 2011; Tamas & Mosler, 2011), arsenic-removing sand filters (Tobias & Berg, 2011), arsenic-safe deep tubewells (Mosler, Blöchliger, & Inauen, 2010), and the consumption of fluoride-free water (Huber & Mosler, 2012; Huber, Bhend, & Mosler, 2012). The practical implication of the approach is that if interventions manage to modify these social-cognitive determinants, this will lead to greater behavior change effects (Conner & Norman, 2005; Mosler, 2012). There is some evidence that this assumption may hold (Abraham & Sheeran, 2005; Luszczynska & Tryburcy, 2008), but generally, the evidence has been mixed (Norman & Conner, 2005). The reasons for this are manifold (Norman & Conner, 2005). They include factors that are inherent in the theory that the interventions are based on, e.g. limited predictive utility or lack of specification (e.g. the Transtheoretical Model of Change [TTM]), or failure to specify how the determinants can be targeted. On the other hand, lack of methodological rigor of intervention studies may be a further explanation for null effects (e.g. lack of randomized trials, no appropriate comparison groups, no measurement or analysis of potential mediators). Overall, Michie and Prestwich (2010) appeal for applying theory more stringently at every step from intervention development to evaluation. Figure 1 depicts the steps required for developing theory-based interventions (Michie, Johnston, Francis, Hardeman, & Eccles, 2008).

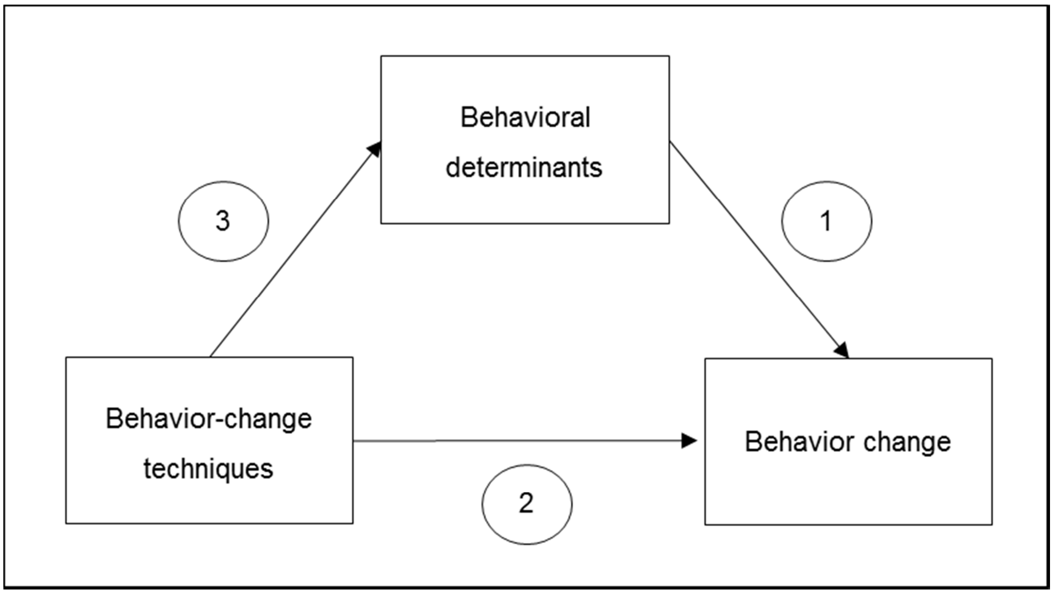

Figure 1. Schematic display of developing theory-based interventions (adapted from Michie et al., 2008): (1) Identify behavioral determinants of the target behavior; (2) identify behavior change techniques (BCTs); and (3) BCTs are mapped on to the behavioral determinants.

First, behavioral determinants have to be identified that can explain or predict the target behavior. To accomplish this, behavioral determinants from evidenced theory have to be compiled (rather than using a single theory, cf. Abraham, 2012), and the most potentially impactful determinants must be identified. Second, behavior change techniques (BCTs) to alter the target behavior must be identified. Finally, the links between the BCTs and the behavioral determinants need to be established, i.e. it has to be determined, which of the BCTs alter which behavioral determinants (Michie et al., 2008).

This approach will be applied in the present thesis for the case of safe water consumption. In this chapter, information regarding the target behavior, arsenic-safe water consumption as an example for safe water consumption, will first be presented. Thereafter, a theoretical framework for developing interventions will be compiled from health behavior theory. Furthermore, methods for developing theory-based interventions will be described, and BCTs will be linked to the specific behavioral determinants. In the final sections of this chapter, this thesis' research questions will be summarized, and an overview of the studies conducted will be given. The subsequent Chapters II, III, IV, and V depict the empirical research that was carried out. They form the core part of this thesis. In the end, Chapter VI displays a general discussion of the overall findings, including implications for theory and practice, a critical appraisal of this research, and concluding remarks.

2. Arsenic in drinking water

Geogenic arsenic in groundwater affects approximately 100 million people worldwide (Ahmed et al., 2006). Bangladesh is the most affected country, with at least 20 million people at risk of drinking water above the national guideline of 50µg of arsenic per liter (Johnston & Sarker, 2007). Other affected countries include the USA (Shaw, Walker, & Benson, 2005), Argentina (Bundschuh et al., 2004), Cambodia (Buschmann, Berg, Stengel, & Sampson, 2007) and others more (Amini, Abbaspour et al., 2008).

Arsenic is a metalloid which naturally occurs in the environment (Hughes, Beck, Chen, Lewis, & Thomas, 2011). It is highly toxic and has been recognized as a carcinogen (Hughes et al., 2011). By complex chemical processes, arsenic is leached from aquifer rocks and sediments and accumulates in groundwater (Smedley & Kinniburgh, 2002). Making detection cumbersome, arsenic is not equally distributed in a given territory; while a well can be found arsenic contaminated, a neighbor's well may be arsenic-safe and vice versa. The main uptake pathway of geogenic arsenic is through drinking water, but cooked food is a further contributor (Ohno et al., 2007).

Health effects of excessive arsenic intake are diverse. Arsenicosis, the term summarizing symptoms of arsenic poisoning, develops slowly over a period of several years. The consequences of arsenic accumulation in the body are therefore not immediately perceptible, and neither is arsenic, being tasteless, odorless, and colorless. In the earlier stages of arsenicosis, different forms of skin alterations occur (Ahsan et al., 2006). These can ultimately lead to cancers of the skin, bladder, or lung (Chen & Ahsan, 2004). Further associated diseases are peripheral vascular diseases (e.g. blackfoot disease), cardiovascular diseases (Chen et al. 2007), and impaired neurodevelopment in children (Wasserman et al., 2004). The prevalence of arsenicosis is difficult to estimate. In West Bengal, 300’000 skin lesions due to arsenic exposure have been reported and there are likely to be more in neighboring Bangladesh (Chakraborti et al., 2004).

2.1. Mitigating arsenic contamination

Mitigating arsenic contamination of drinking water is a multi-faceted issue, particularly in locations where drinking water supply is household based, and when financial resources for safe water alternatives are lacking. Recently, in a multi- and transdisciplinary project, researchers at Eawag, the Swiss Federal Institute of Aquatic Science and Technology have developed a framework describing the steps that need to be taken to mitigate geogenic contamination (Johnson et al., 2012). The framework includes procedures to assess the extent of geogenic contamination in a given region (i.e. assessment and modeling of water quality, water availability, and human contaminant uptake). Furthermore, procedures to mitigate the detected contamination are described. These highlight that a multidisciplinary expertise is required to mitigate geogenic contamination. Natural scientists and engineers need to identify the most appropriate technical solutions for a specific region (e.g. arsenic-safe water options), whereas sociologists or political scientists need to assess the institutional support for the technical solutions. Furthermore, psychologists need to determine the acceptance of the technical solutions and develop behavior change strategies to promote their use. The three elements of mitigation are not sequentially ordered but rather inform each other multidirectional. For example, results on the acceptance of safe water options can indicate the need for technical improvements of the options (e.g. to improve the taste of filtered water).

The present research represents the behavioral part of a case study that aimed at testing the proposed framework for arsenic contamination.

Bangladesh was selected as the study location because of the unique magnitude of the issue there. In the following, a brief overview of arsenic contamination and mitigation in Bangladesh is provided.

2.2. Arsenic in Bangladesh

Until the 1970ies, most Bangladeshi people consumed pond water for drinking. Ponds often suffer from microbial contamination, wherefore groundwater for drinking was promoted to mitigate consequential cholera epidemics (Atkins, Hassan, & Dunn, 2007a). In what seemed like an outstandingly successful promotion campaign by the Government of Bangladesh (GoB), UNICEF, and other aid agencies at the time, millions of mechanic tubewells were drilled into shallow aquifers, soon delivering groundwater to the vast majority of the rural population (Hoque et al., 2004). However, by the 1990ies, increasing numbers of cases with skin lesions were discovered in West Bengal and shortly thereafter in Bangladesh. These were soon linked to the occurrence of excessive arsenic in groundwater. In response to this discovery, a well-testing campaign of five million hand tubewells showed that approximately every fifth well was contaminated with arsenic above Bangladesh’s national guideline of 50 µg/l (Johnston & Sarker, 2007). Excessive arsenic was found in 62 of 64 districts, with 47 districts featuring more than 5% and 6’062 villages featuring 80% to 99% contaminated tubewells (Johnston & Sarker, 2007). The estimated numbers of initially exposed people in Bangladesh range from 35 million to almost 80 million people, which represents “the largest mass poisoning of a population in history” (Smith, Lingas, & Rahman, 2000, p. 1093).

The well-testing campaign was an important first step in the mitigation process. Wells that were tested arsenic-contaminated were subsequently painted red, arsenic-safe wells were painted green. Overall, it has been estimated that the well-testing and communication of risk prompted 10 million people (29% of the initially exposed) to switch from their drinking water source to collect water from their neighbor’s safe wells (referred to as well-switching or well-sharing; Ahmed et al., 2006). Above this, natural scientists, engineers, the GoB, bilateral and multilateral agencies (e.g. UNICEF), and numerous non-governmental organizations (NGOs) have been developing and implementing affordable arsenic-safe water options which are described next.

Arsenic-safe water options

In 2004, the GoB published a policy (GoB, 2004b), and an implementation plan for arsenic mitigation (GoB 2004a), which lists the following safe water options: deep tubewells, dugwells, pond sandfilters, large scale surface water treatment, rainwater harvesting, arsenic removal options and piped water supply (see Figure 2). The arsenic removal options can further be separated into household-based options (e.g. the Sono filter; Hussam & Munir, 2007), and community-based options.

By 2006, more than 100’000 safe water options had been installed (Kabir & Howard, 2007), and approximately 15 million initially exposed people gained access to arsenic-safe water options, leaving approximately 20 million people at risk (Ahmed et al., 2006).

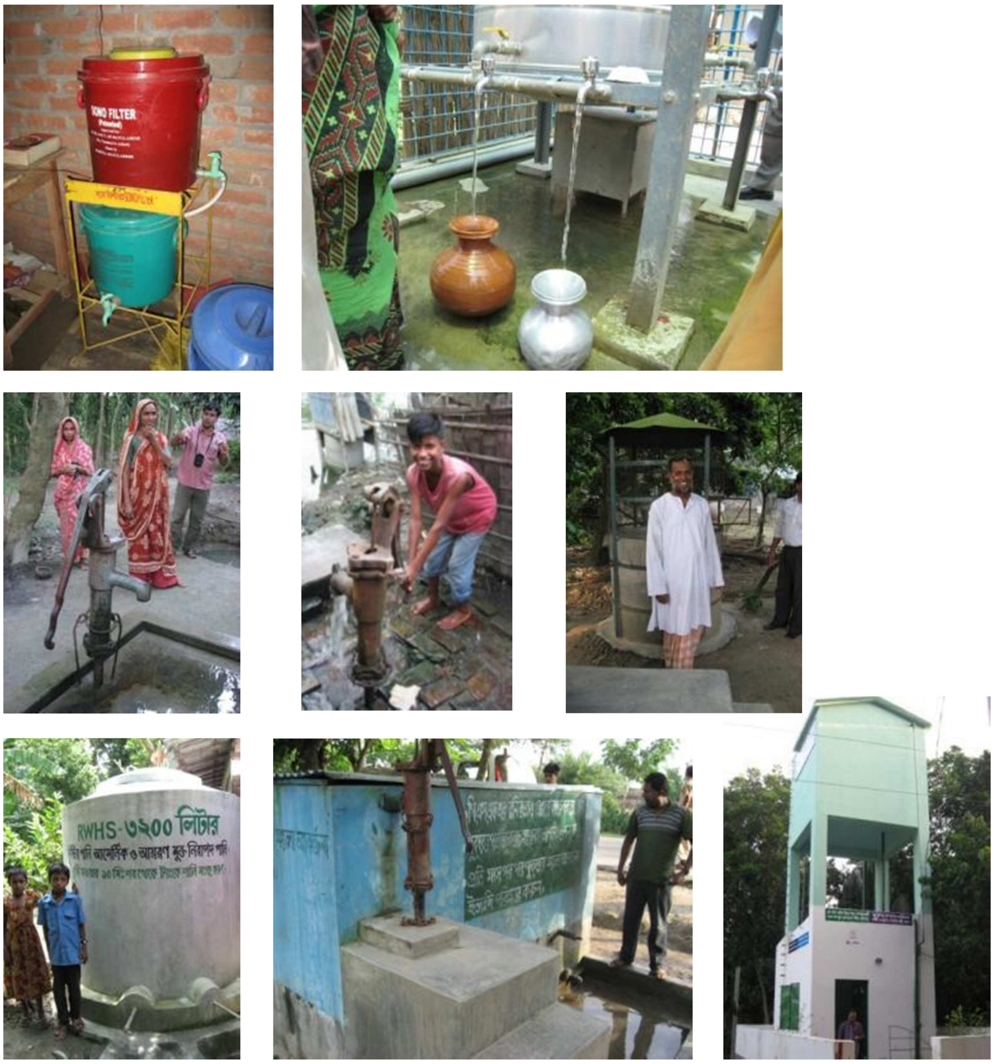

Figure 2. Arsenic safe water options currently implemented in Bangladesh (from top left to bottom right): Household & community arsenic-removal, deep tubewell, well-switching, dug well, rainwater harvesting, pond sand filter, piped water supply.

As mentioned above, most people started sharing safe wells of their neighbors. Of the implemented mitigation options, community-based deep tubewells were by far the most frequently installed by 2006, even though the GoB had prioritized surface water over groundwater options (indicating institutional conflicts that have been hampering mitigation; Atkins et al., 2007a, 2007b). Other safe water options, such as arsenic removal methods, use of surface water or rainwater harvesting have only played a minor role in arsenic mitigation so far (Ahmed et al., 2006). There is no reliable information, how many people actually use the installed options, but it has been reported that a proportion of these are not used or maintained by the beneficiaries (e.g. Opar et al., 2007). Knowledge regarding this would be important. For example, to know whether a specific water option is used by most of the people, whereas others are hardly used at all would provide stakeholders with vital information regarding people’s acceptance of the options. Moreover, knowing what people like or dislike about which of the different options would have important implications, not only for behavior change interventions. Institutions could make more informed decisions, which options to implement or how to refine them so that they would be used by the population.

Behavior change efforts

Regardless the topic, it is being increasingly recognized that innovations (e.g. safe water options, hygiene practices) are hardly self-promoting (Rogers, 2005). They must always be accompanied by “software” approaches, i.e. behavior change interventions (Mosler, 2012). This is also state of the art for most development agencies in Bangladesh, where installation of safe water options is frequently accompanied by awareness campaigns of varying success. However, systematic evaluations of behavior change campaigns, in vast contrast to the massive number of natural science publications on arsenic, are mostly absent, making it difficult to estimate the effectiveness of the interventions. The few published studies usually combined well testing with education, and reported decreased use of arsenic-contaminated water due to their interventions (e.g. George, van Geen et al., 2012; Hanchett, Nahar, Van Agthoven, Geers, & Rezvi, 2002; Hoque et al., 2004). Caldwell et al. (2006), for example, reported 3.5% switching to safe sources and 0.6% who started to filter their water after their campaign. Others report approximately 40% switching to safe sources (Hanchett et al., 2002; Hoque et al., 2004). Greatest behavior change impact was achieved by a well-switching campaign of Opar and colleagues (2007); 65% of respondents switched to alternative water source. However, people often switched to untested wells (Opar et al., 2007). A further preoccupying finding is that potentially arsenic contaminated shallow tubewells are still being constructed, despite increased risk awareness (Opar et al., 2007; van Geen et al., 2002), indicating the need for further well-testing. Interestingly, some studies found that well-switching rates increased with increased arsenic contamination (e.g. Tarozzi, Balasubramanya, Bennear, & Pfaff, 2009; Madajewicz et al., 2007). Furthermore, well-switching rates have been found to decrease with increased distance to safe wells (George, van Geen et al., 2012; Opar et al., 2007), and well ownership (George, van Geen et al., 2012). Overall, however, despite some encouraging results, the effects of communicating contamination are equivocal (Lucas, Cabral, & Colford, 2011). According to Lucas et al. (2011), this is due to the studies' lack of appropriate control groups, lack of theoretical background, and poor intervention description. The latter makes it particularly difficult to identify the "active ingredients" of interventions that caused the behavior change. "Educational" interventions frequently contain further BCTs than risk information (e.g. concomitant installation of safe water points, Chen et al., 2007; Opar et al., 2007). Nevertheless, researchers frequently attribute their intervention effects to people's increased knowledge, even when knowledge change was not significantly associated with well-switching (e.g. George, van Geen et al., 2012), and in the absence of mediation analyses (Tarozzi et al., 2009). Madajewicz et al. (2007), for example conclude on the mode of operation of their intervention effects: "We identify a causal effect of information, since incidence of arsenic is uncorrelated with household characteristics." (p. 731). Without formal assessment, such conclusions are invalid, because, as Weinstein (2003) puts it, "[j]ust because people act in ways that protect their health does not mean that risk reduction is the reason for these actions." (p. 22). The few theory-based, quantitative studies on the determinants of arsenic-safe water consumption indicate that further cognitions may be relevant to explain risk mitigation behavior. Severtson, Baumann, & Brown (2006) applied the Common Sense Model (CSM; Leventhal, Brissette, & Leventhal, 2003) to predict protective behavior against arsenic uptake among owners of arsenic-contaminated private wells in the USA. The results of a cross-sectional survey revealed the association of information (well status) with protective behavior, but perceived water quality (e.g. taste and smell) was equally influential (Severtson et al., 2006). Mosler and colleagues (2010) assessed behavioral determinants from the Protection Motivation Theory (PMT; Rogers, 1983), and the TPB (Ajzen, 1991) among users and non-users of arsenic-safe deep tubewells in Bangladesh. They also found an association of water taste with people's safe water consumption, but interestingly, normative influences (particularly the perception whether others also consume arsenic-safe water, i.e. the descriptive norm), and self-efficacy (the confidence in one's ability to collect safe water) emerged as the most important explanatory factors of arsenic-safe water consumption (Mosler et al., 2010). Although both studies yielded interesting insights into the determinants of arsenic-safe water consumption, some potentially important behavioral determinants were not included (e.g. commitment, cf. Mosler, 2012). Furthermore, only one arsenic-safe water option was studied in one cross-sectional survey.

In conclusion, while behavior change efforts in Bangladesh have had some success, only few studies have been conducted that have systematically investigated the behavior change effects of the implemented interventions. Regarding the determinants of arsenic-safe water consumption, theory-based research in this domain is mostly absent. While some indications of potentially important behavioral determinants were identified, more comprehensive studies are required. These would ideally include all of the implemented arsenic-safe water options in Bangladesh, and consider a comprehensive selection of potentially influential social-cognitive behavioral determinants. This would render a sound basis for developing theory-based interventions to enhance the use of arsenic-safe water options.

The following sections aim at acquiring a comprehensive theoretical foundation that will allow for developing and testing theory-based interventions to promote safe water consumption. First, the possible determinants of safe water consumption are compiled from a review of health behavior theories. Thereafter, approaches for the development of theory-based interventions are presented, and BCTs will be linked to the behavioral determinants.

3. Social-cognitive determinants of health behavior

As eluded above, the social cognition approach assumes that individuals' cognitions mediate the relationship between external influences and their behavior (Fiske & Talyor, 1991), and that behavior is better understood by taking into account people's perceptions of the external influences than by an objective measure of these (Conner & Norman, 2005).

With regards to developing theory-based interventions, an important question is whether a particular theory should be selected as the theoretical basis, or whether determinants of several theories should be combined. Lippke and Ziegelmann (2008) argue that this decision depends on the goal of the endeavor. To test a particular behavior change theory, the authors recommend selecting a single theory. However, when the goal is to maximize intervention effectiveness, as it is in the present thesis, compiling determinants from several theories is the approach of choice

(Lippke & Ziegelmann, 2008). The integration of several theories is also in line with Abraham (2012), who argues that by selecting only one theory, one would run the risk of omitting important behavioral processes: “Until theoretical integration develops further in the behavioural sciences, intervention designers will need to consider a range of change processes, necessitating consideration of multiple theories.” (Abraham, 2012, p. 110). Moreover, the integration of theories may even be beneficial for theory development itself, because there is significant overlap between current theories (Conner & Norman, 2005; Leventhal & Mora, 2008). The present thesis will therefore aim at integrating major social-cognitive theories of health behavior to a framework that can serve as a basis for deriving theory-based interventions. This framework will be presented after the following review of major health behavior theories.

3.1. Health behavior theories

This section first discusses continuum models of health behavior, where after an overview of health-related stage theories and integrative models will be presented. In the end, a model compiling the most important factors identified is displayed.

Continuum theories

These are theories that assume behavior to be a continuum and that the likelihood of behavior performance can be predicted by the strength one or more behavioral determinants (Sutton, 2005). The major continuum theories of health behaviors are presented below.

The health belief model (HBM)

The Health Belief Model (HBM; Becker, Drachman, & Kirscht, 1974; Rosenstock, 1966) is possibly the oldest and most widely applied health-related social-cognition model (Conner & Norman, 2005). In principle, the theory proposes that health-related actions are rendered more likely the stronger the individual perceives a threat, and the higher the effectiveness of the health behavior to avoid this threat is estimated (Becker et al., 1974). Threat perceptions are further divided into perceived susceptibility and perceived severity. Perceived susceptibility (also termed vulnerability) represents the personal likelihood of being personally affected by a health threat, e.g. arsenicosis. Perceived severity, on the other hand, represents the perceived negative consequences of the threat, e.g. to face social exclusion when affected by arsenicosis. The effectiveness of the health behavior is assumed to be determined by the perceived utility and the perceived barriers to performing a behavior

(Becker et al., 1974). Later on, the HBM was further augmented with predisposing factors (demographic and psychological, e.g. gender, personality), and with cues to action and health motivation (Abraham & Sheeran, 2005). Health motivation is the value of personal health, whereas cues to action represent external (e.g. communication) and internal (e.g. symptoms of arsenicosis) triggers of health behavior (Abraham & Sheeran, 2005).

The HBM has been applied to a wide range of health behaviors and the constructs of the HBM have generally shown to be useful, even though effect sizes are usually small (see Abraham & Sheeran, 2005). A review of HBM-based interventions yielded successful behavior change for 13 out of 17 (76%) studies (Abraham & Sheeran, 2005). However, some studies had methodological flaws (e.g. lack of control groups), and for lack of mediation analyses, no actual conclusions on the usefulness of the HBM for intervention planning can be drawn (Abraham & Sheeran, 2005). In fact, in some studies, HBM predictors did not even add to explaining the behaviors at hand (e.g. Lu, 2001).

In conclusion, while the HBM, perhaps due to its parsimony, has been frequently applied to explain, predict, and modify a variety of health behaviors, effect sizes are usually small or not clearly attributable to HBM variables (Abraham & Sheeran, 2005). A further criticism of the HBM is the missing specification of the relationships between its predictors (Abraham & Sheeran, 2005). Finally, it has been suggested that important constructs are missing (i.e. behavioral intention and self-efficacy), which may augment the predictive power of the HBM. In the following theory, some of these limitations were overcome.

Protection Motivation Theory (PMT)

Similarly to the HBM, PMT (Rogers, 1975, 1983) proposes two appraisal routes: threat appraisal (i.e. perceived threat), and coping appraisal (i.e. perceived effectiveness of a health behavior). In PMT, however, these processes are further specified. Threat appraisal focuses on the maladaptive response (e.g. drinking arsenic-contaminated water). It is assumed that perceived severity and vulnerability are weighed against intrinsic and extrinsic rewards of the maladaptive response. For example, although someone feels vulnerable to develop arsenicosis and judges its consequences as severe, he or she may also perceive social approval from his or her neighbors for collecting water from the contaminated well (i.e. extrinsic reward), and may appreciate the proximity of the well (i.e. intrinsic reward). In addition, to the HBM, PMT proposes that fear may result from the appraised severity of and vulnerability to the threat, which, in turn, will promote protection motivation (Norman, Boer, & Seydel, 2005), i.e. behavioral intention. Coping appraisal, on the other hand, focuses on the adaptive response. It is proposed that the belief that the new behavior is effective to overcome the threat (i.e. response efficacy), and the perceived confidence in one's abilities to perform the new behavior (i.e. self-efficacy; Bandura, 1977) are weighed against the costs involved in performing the new behavior (e.g. the additional time required to collect water, Norman et al., 2005). According to the original theory, protective action is more likely when protection motivation is high. This, in turn, is higher when severity and vulnerability outweigh the rewards of the maladaptive response, and when response efficacy and self-efficacy outweigh the response costs of the new behavior. Since empirical evidence of these combinational rules have been lacking, however, most empirical investigations have focused on direct effects of the variables on protection motivation or behavior (Norman et al., 2005).

Like the HBM, PMT has been successfully applied to predict a series of health behaviors, (see meta-analyses by Floyd, Prentice-Dunn, & Rogers, 2000; Milne, Sheeran, & Orbell, 2000). Generally, the variables of threat appraisal (i.e. vulnerability and severity) have had weaker effects on intention and behavior than factors of coping appraisal (Norman et al., 2005). Of the latter, self-efficacy and response costs were the strongest predictors of health behaviors besides behavioral intentions (Norman et al., 2005). Even for those factors, however, effect sizes dropped to below medium when predicting future behavior (Milne et al., 2000). Intervention studies based on PMT are rare, and with few exceptions (Rippetoe & Rogers, 1987) did not investigate whether changes in PMT cognitions mediate intervention effects on behavior change (Norman et al., 2005).

Norman et al. (2005) conclude that while PMT has a sound theoretical foundation, it has mainly been supported by correlational studies. Various issues need to be resolved by experimental studies, preferably intervention studies that measure changes in cognitions in natural settings, and at a later time than immediately after manipulation (Norman et al., 2005). In favor of the theory, considering beliefs regarding the alternative behavior seems promising. Furthermore, self-efficacy was included, which is a focal variable in the next theory.

Social-Cognitive Theory (SCT)

The central element of Social-Cognitive Theory (SCT; Bandura, 1977, 2001) is self-efficacy. Bandura (2001) states that "[u]nless people believe they can produce desired results and forestall detrimental ones by their actions, they have little incentive to act or to persevere in the face of difficulties.” (Bandura, 2001, p. 10). SCT proposes effects of self-efficacy on behavior to take place both directly and indirectly through influencing all other determinants of the theory: outcome expectations, sociostructural factors, and goals. Outcome expectations, in similarity to the aforementioned risk perception factors, response efficacy, and response costs, can be physical (e.g. better health when collecting safe water), social (e.g. lower social status), and self-evaluative (e.g. fitting with personal standards). A unique feature of SCT is that these expectations, besides influencing goals (understood as a continuum from distal to proximal goals), can exert direct effects on behavior. Sociostructural factors (impediments and facilitators), in turn, are thought to mediate self-efficacy effects on goals. Thus, according to SCT, one’s confidence in the ability to perform an action influences an individual’s perception of impediments (e.g. no safe water source available) and facilitators (e.g. social support to collect water).

Adding self-efficacy in particular, but also outcome expectations as further proximal determinants of behavior are achievements of SCT. Also, it is one of the few psychological theories that differentiate between what Conner and Norman (2005) termed action-outcome expectancies (in SCT termed outcome expectations), and situation-outcome expectancies (i.e. sociostructural factors). However, by assuming that sociostructural factors mediate the self-efficacy-goals relationship, the theoretical impact of impediments and facilitators on behavior is minimized. This implies that given that impediments are perceived severe enough, no intentions are formed. Furthermore, it is implied that any obstacle to behavior performance can be overcome, if only one’s confidence in oneself is strong enough. For example, not being able to afford to buy an arsenic-removing filter would then be attributed to low self-efficacy in one’s capabilities to economize. However, it is also imaginable that there are situations where impediments cannot be compensated by increased self-efficacy, e.g. when people just do not have money to set aside.

In conclusion, despite this minor criticism, SCT is an influential theory that has been successfully applied to behaviors of various domains (see Luszczynska & Schwarzer, 2005). Furthermore, SCT has an important and rare feature: it specifies how its key determinant, self-efficacy, can be modified. Bandura (1986) proposes four sources of self-efficacy: mastery experience (i.e. performing the behavior), vicarious experience (i.e. observing models performing the behavior), symbolic experience (i.e. verbal persuasion by others that one can perform the behavior), and emotional arousal (i.e. inferring one’s competence from emotional reactions to behavior performance). However, evidence on the effectiveness of SCT-based interventions is mixed (Luszczynska & Schwarzer, 2005). From the review of intervention studies provided by Luszczynska and Schwarzer (2005), it seems that this may at least partly be due to lack of rigorous adherence to SCT for developing and evaluating the interventions.

Theory of Planned Behavior (TPB)

In the TPB (Ajzen, 1985, 1991), intentions are directly predicted by attitudes towards the behavior (beliefs about the consequences of the behavior and their evaluation), the subjective norm to perform a behavior (belief about others' expectations, and willingness to comply with these), and the perceived behavioral control to perform a behavior (perceived difficulty of the behavior). These factors, in turn, predict behavioral intention, which together with perceived behavioral control predicts behavior (Ajzen, 1991). The TPB is a social psychology theory and specifically tailored to explain health behaviors. At first glance, risk perception variables, for example, are missing. However, at closer scrutiny, most of the above mentioned variables can be incorporated into the model. Attitude, for example, is determined by beliefs about the outcomes of the behavior (e.g. perceived susceptibility, response efficacy), and the subjective value thereof (e.g. severity) (Conner & Norman, 2005). Also, it has been found useful to further distinguish two types of attitudes (Trafimow & Sheeran, 1998). Instrumental attitude captures cost-benefit beliefs, whereas affective attitude represents anticipated emotional reactions (Trafimow & Sheeran, 1998). Perceived behavioral control, on the other hand, has been equated with self-efficacy (Schwarzer, 2008), and protection motivation can be equaled with behavioral intention (Norman et al., 2005). Being a social psychological theory, the particularity of the TPB is the prominence of social factors in the model (Weinstein, 1993). Empirically, however, the subjective norm (frequently simplified to the injunctive norm, i.e. other people's approval of the behavior, Cialdini, 2003) is often the weakest predictor of intentions (Conner & Sparks, 2005). Another social influence that has been suggested to be included is the descriptive norm, i.e. the perceived behavior of others (e.g. whether other people also collect water from arsenic-safe wells) (Cialdini, 2003). This factor has been shown particularly important to explain safe water consumption (Heri & Mosler, 2008; Huber & Mosler, 2012; Mosler et al., 2010).

The TPB has been widely researched and proven useful to explain and predict several health behaviors (see Conner & Sparks, 2005). Particularly appealing is the parsimony of the model and the clear specifications of constructs. However, the TPB does not offer clear directions, how to manipulate its behavioral determinants (Conner & Sparks, 2005). While a review of TPB based interventions yielded behavior change effects in two-thirds of the studies, effects were generally small, and only half of the interventions were actually based on the TPB (Hardeman et al., 2002). A further shortcoming of the theory is that while intentions are usually well explained by its predictors, behavior is not. In a meta-analysis of the TPB by Sheeran (2002), for example, up to 80% of variance in behavior remained unexplained.

This phenomenon is generally referred to as the “intention-behavior gap” (e.g. Knoll, Scholz, & Rieckmann, 2011), and is a collective criticism of the above described continuum theories. The common finding that people do not always act according to their intentions cannot be attributed to differences in motivation of intenders who act and intenders who do not (Orbell & Sheeran, 1998). Rather, it seems like at time of behavior performance people may decide or to be prompted to follow competing intentions, e.g. due to giving into temptations (e.g. drink directly from the contaminated well because they are thirsty), being persuaded by others to act differently, or because of unexpected obstacles (e.g. a sick child they need to care for instead of going to the safe well).

Factors that help translate intentions into actions are termed post-motivational (also post-intentional) or volitional factors (Heckhausen, 1989). Of the continuum theories, only SCT proposed post-motivational factors to predict behavior: self-efficacy (Bandura, 1997). However, there are more to be considered, such as planning (Gollwitzer, 1999; Schwarzer, 2008), and commitment (Tobias, 2009). Theories that have incorporated these factors belong to the stage theories, which will be discussed in the following sections.

Stage theories

Stage theories share common features that strongly distinguish them from the theories discussed in the preceding section. In contrast to continuum models, they assume that behavior change is achieved by sequentially proceeding through qualitatively distinct, discrete stages of change (Schüz, Sniehotta, Mallach, Wiedermann, & Schwarzer, 2009). The outcome in stage theories is not behavior, but the transitions between the stages, which are predicted by different psychological and other factors (Schüz et al., 2009). Within one stage, homogeneity of the individuals is assumed (Sutton, 2005). Consequently, stage theorists assume that interventions need to be tailored to the individual’s current stage in order to promote proceeding to further stages. To ascertain people’s stages, most theories propose staging algorithms, of which some are based on time spans regarding different variables (e.g. whether behavior change is intended within the next six months; Prochaska & DiClemente, 1983), and others are based on the characteristics of psychological predictors (e.g. Weinstein, 1988). The number of stages varies between the theories. Some have proposed three stages, (e.g. the Integrated Change Model [I-Change Model]; de Vries, Mesters, van de Steeg, & Honing, 2005), whereas other models contain four (Model of Action Phases [MAP]; Heckhausen, 1989), five (e.g. the Innovation-Decision Process, Rogers, 2005), seven (Precaution Adoption Process Model [PAPM]; Weinstein & Sandman, 1992), or even eight different stages (the Multi-Stage Model of Health Behavior Change; Lippke & Ziegelmann, 2006). In the following, two stage theories will be described to exemplify the stages approach to health behavior change.

The Transtheoretical Model of Change (TTM)

Probably the oldest and most widely researched stage model is the TTM (Prochaska & DiClemente, 1983). In its most frequently used version, the TTM proposes five stages of change: precontemplation, contemplation, preparation, action, and maintenance (Prochaska & DiClemente, 1983). The TTM’s predictors of stage transitions (i.e. its independent variables) are decisional balance (pros and cons of behavior), self-efficacy (confidence and temptation), processes of change (e.g. consciousness raising, i.e. finding new facts etc.), and behavioral processes (e.g. stimulus control, i.e. adding reminders; Prochaska, Redding, & Evers, 2002). Each of these categories contains a variety of factors, demonstrating the increased complexity of stage theories compared to continuum models. In fact, if correctly specified, each stage of change is predicted by its own causal model of determinants (Sutton, 2005). To test stage theories, experimental, longitudinal research designs are required. However, unclear operationalization of the predictors of stage transitions of most stage theories hampers such investigations (Sutton, 2005). One theory, however, that has overcome this criticism, and may therefore have gained popularity fast is the HAPA.

The Health Action Process Approach (HAPA)

The HAPA (Schwarzer, 1992, 2008) is one of the most recent stage theories. It integrates several social-cognitive factors of the aforementioned theories, e.g. SCT, and proposes at least two stages: motivation and volition (Sutton, 2005). More stage definitions include preaction, intention, action, or an even further division of the action stage into initiation, maintenance, and recovery (Sutton, 2005). However, the definition of the HAPA as a stage model has been criticized (Sutton, 2005, 2008), because it is specified and frequently applied as a causal model that strongly resembles the continuum theories discussed above. The HAPA proposes action self-efficacy (also termed pre-action or motivational self-efficacy), outcome expectancies, and risk perception to determine intention, which in turn influences behavior (Schwarzer, 2008). So far, the theory strongly resembles the TPB. However, in an effort to bridge the intention-behavior gap (Sutton, 2008), planning was added as a mediator between intention and behavior.

Planning emerged mportant to translate intentions into actions by Gollwitzer’s work on implementation intentions (e.g. Gollwitzer, 1999). Implementation intentions (or action plans), are simple plans regarding the when, where and how behavior is to be performed (Sheeran, Milne, Webb, & Gollwitzer, 2005). For example, “when my children have gone off to school, I will go to collect water from my neighbor’s arsenic-safe water source”. While forming behavioral intentions specifies what will be done, implementation intentions help to carry out the action, and are therefore considered volitional factors (Sheeran et al., 2005). The HAPA defines coping planning as a further form of planning, which is in fact the forming of implementation intentions to overcome specific barriers (Sheeran et al., 2005).

A further particularity of the HAPA is the incorporation of phase-specific self-efficacies: the confidence in one’s ability to overcome barriers (maintenance or volitional or coping self-efficacy) or to recover from setbacks (recovery self-efficacy) (Schwarzer, 2008).

Empirical support for the model to predict a series of health behaviors in different cultures has been accumulating fast (Schwarzer, 2008). Studies testing the HAPA often employ longitudinal (e.g. Luszczynska & Schwarzer, 2003), and experimental designs (e.g. Sniehotta, Scholz, & Schwarzer, 2006). However, in most studies, the HAPA has been tested as a continuum theory, supporting Sutton’s (2005) remark that the HAPA is not a genuine stage model. Studies testing stage-tailored interventions yield some support for the HAPA (Lippke, Schwarzer, Ziegelmann, Scholz, & Schüz, 2010), but careful mediation studies have shown that the same cognitive mechanisms can explain individuals’ in different stages of change, contradicting the stage approach (Luszczynska, Goc, Scholz, Kowalska, & Knoll, 2011).

From an intervention planning perspective, a shortcoming of the HAPA is the broad consideration of outcome expectancies. Items regarding social, physical, and emotional outcome expectancies are combined into a single factor, which leaves no detailed idea, which of the three dimensions to target. Another criticism concerns the HAPA’s claim that planning bridges the intention-behavior gap (Schwarzer, 2008). Sutton (2008) demonstrates that while the addition of planning as a mediator of the intention-behavior relationship will likely increase the explained variance of behavior change, it does not add explanation; people with higher intentions rather plan their actions, and, consequently, exert higher behavior change. It thus only explains why people enact their intentions, but not why some rather do and others do not. Bridging the intention-behavior gap is thus a question of moderators or adding proximal behavioral determinants. One such factor is commitment strength, which assumes a crucial role in Tobias’ (2009) model of habit development that will be discussed next.

The Model of Prospective Memory and Habit Development (MPMH)

The MPMH is a recent, dynamic model that was developed to explain the effects of memory aids (or reminders) on behavior change (Tobias, 2009). In its essence, the MPMH proposes that behavior is only performed when it is feasible, preferred, and remembered at the time of behavior execution (Tobias, 2009). Preferences are assumed to be influenced by the above discussed motivational factors (i.e. convictions, norms, affect) as well as tension states (Tobias, 2009). The core part of the model is remembering, which is proposed to be influenced by the behavior’s situational accessibility, and the availability of cognitive resources and habits for the behavior. Accessibility of a behavior is influenced by various factors, such as previous behavior performance, forgetting, events, and situational cues (e.g. reminders). Importantly, effects of events and situational cues on accessibility are assumed to be contingent on commitment strength; “The strength of any form of internal pressure felt by a person to perform a behavior” (Tobias, 2009, p. 411). An example: A person prefers collecting arsenic-safe water (e.g. because the water is tasty, and family members approve), and has no obstacles for doing so (i.e. behavior is feasible). The person, however, has no habit of performing the behavior, and is occupied with other tasks (i.e. low cognitive resources). Assuming that nothing reminds this person of going to collect safe water, this person will not perform the behavior. However, if somebody (e.g. a promoter) or something (e.g. a poster) prompts the person to collect safe-water, the person will perform the behavior, provided he or she is committed enough to doing so.

Tobias (2009) validated his model with dynamic field data and agent-based computer simulation, and has found strong support for his assumptions. The MPMH deserves merit for being the only true process model that was found in the current health behavior literature. Only with these types of models can behavior change as a process truly be predicted. Unfortunately, such models are even more complex than the above discussed stage models, and are therefore impractical for statistical investigations. Furthermore, key variables of the model are hard to assess by self-report (e.g. accessibility). Finally, self-efficacy is not represented in the model, although it may be reflected in the feasibility of the behavior. Nevertheless, commitment strength and remembering emerged as possibly important constructs for the behavior change process. They can be measured by questionnaire, and have been shown influential to explain water consumption behavior (e.g. Huber & Mosler, 2012). Tobias' work further highlights the importance of habits, a construct that has received increasing attention in the behavior change literature and shall be discussed in the following.

Habit

In a further effort to explain intention-behavior discrepancies, the concept of habit, at first equated with past behavior, emerged. Wong and Mullan (2009), for example, successfully added past behavior to the TPB to predict current breakfast consumption. However, habit is increasingly understood as a mental construct that exhibits features above repeated behavior (Verplanken, 2006). According to Aarts, Verplanken, and van Knippenberg (1998), habits are goal-directed, automatic, mentally represented behaviors. Similar to implementation intentions, they are assumed to strengthen links between situational cues and behavior. Thereby, accessibility of the behavior is facilitated, which is assumed to lead to automatic behavior performance at appearance of the cue (Aarts et al., 1998). Habits can be reliably measured by self-report (the Self-Report Habit Index [SRHI], Verplanken & Orbell, 2003), and have been proven influential to predict a series of health behaviors (e.g. fruit consumption, de Bruijn, 2010; condom use, Stacy, Stein, & Longshore, 1999; smoking reduction, Webb, Sheeran, & Luszczynska, 2009; physical exercise, Verplanken & Melkevik, 2008). One criticism is, however, that habits are partly redundant with behavior because they also reflect past behavior (Ajzen, 2002). Consequently, habits are highly correlated with current behavior, covering possible effects of cognitions that influenced the establishment of the habits, and the present behavior (Ajzen, 2002). Thus, valuable information on social cognitions that may serve for intervention development may be lost.

Integrative models

The above review of theories show considerable overlap that has also been noted elsewhere (Bandura, 2004; Conner & Norman, 2005; Lippke & Ziegelmann, 2008). An integration of the factors into one model would not only be useful to provide an overview of behavioral determinants that have to be considered when attempting to change a behavior. Furthermore, the integration has been demanded in order to allow advances in health behavior theory development (Leventhal & Mora, 2008; Lippke & Ziegelmann, 2008). Some integrative models have been proposed. These will be discussed in the following, where after the framework for this thesis will be presented.

Major theorists' model

In an effort to combat HIV infections, major health behavior theorists aimed at compiling the most important factors that need to be considered when investigating any behavior (Fishbein et al., 2001). Three predictors of behavior were proposed: environmental constraints, intention, and skills. Intention, in turn, was assumed to be influenced by self-discrepancy, advantages and disadvantages, social pressure, self-efficacy, and emotional reaction (Conner & Norman, 2005).

An advantage is the model's parsimony. However, despite including some of the major social-cognitive variables, the model has some shortcomings. Some important variables are missing (e.g. risk perception, commitment), constructs with doubtful evidence base were included (e.g. self-discrepancy), and no causal relationships between the variables (except for intention) were specified, because the theorists did not achieve agreement on these (Conner & Norman, 2005).

The Theory of Triadic Influence (TTI)

A very comprehensive integration of theory-derived social-cognitive and other factors has been achieved by the Theory of Triadic Influence (TTI; Flay, Snyder, & Petraitis, 2009). Flay and colleagues (2009) make a major distinction between levels of causation (from distal to proximal predictors) and streams of influence (personal, social, environmental). The most proximal behavioral predictor in the TTI is trial behaviors, which is determined by intentions. These, in turn, are determined by self-efficacy and behavioral control, social normative beliefs, and attitudes (as in the TPB). The determinants of intention are again influenced by two levels of distal factors (e.g. self-determination, motivation to comply, knowledge) that are in turn predicted by predisposing factors (e.g. social competence, information), which are ultimately influenced by biology, personality, the social situation, and the cultural environment. The authors further specify that the more proximal predictors are, the more behavior-specific, changeable, and easiest to target in campaigns they are (Flay et al., 2009). However, more proximal predictors are also assumed to exert less long-lasting behavior change effects, which are less generalizable to other behaviors (Flay et al., 2009).

The assembly of factors of the theory is appealing and gives a comprehensive overview of possibilities for behavior change on different levels that is not considered by the other theories. Certainly, for achieving long term behavior change, changes in higher order structures of the society are essential (e.g. banning smoking in public places). However, behavior change efforts are necessary at the individual levels also, because they are usually more immediately achieved compared to societal changes. In this domain, however, the TTI has not made much progress compared to motivational theories as post-motivational factors are lacking.

The RANAS Model (risk, attitude, norms, ability, self-regulation) of Behavior Change

The RANAS is a very recently published behavioral model that aimed at providing a framework for developing and evaluating behaviors of the water, sanitation and hygiene sector (Mosler, 2012). In an effort to overcome shortcomings of existing frameworks in the sector (e.g. Participatory Hygiene and Sanitation Transformation [PHAST], Gungoren, Laptipov, Regallet, & Musabaev, 2007; Community-Led Total Sanitation [CLTS]; Mara, Lane, Scott, & Trouba, 2010), Mosler (2012) compiled major behavioral determinants from health behavior theory. The RANAS specifies as many as 17 factors that were all discussed above. These are grouped into five blocks: (1) Risk factors (perceived vulnerability, severity, factual knowledge); (2) attitude factors (instrumental and affective beliefs); (3) norm factors (descriptive, injunctive, and personal norms); (4) ability factors (action knowledge, self-efficacy, maintenance self-efficacy, and recovery self-efficacy); and (5) self-regulation factors (action control, action planning, coping planning, remembering, and commitment). Mosler (2012) assumes that all of these factors are potential predictors of intentions, behavior, and habit. Furthermore, the RANAS proposes to consider the beliefs of a competing behavior as well (e.g. beliefs regarding contaminated wells). A particularity of the model is that it links BCTs with behavioral determinants, by proposing techniques to change the factors in each block.

The RANAS provides a theoretically based compilation of possible behavioral determinants to be considered when predicting a new behavior, and provides interventions, how to target these. Thereby, the RANAS can be a helpful model for designing and evaluating health-promoting interventions. First applications of the RANAS to safe water consumption support its utility for systematically selecting potentially influential behavioral determinants for intervention (Huber & Mosler, 2012; Huber et al., 2012). A limitation of the RANAS, however, is that it lacks specifications of the interrelatedness of its constructs, which would provide further important information for intervention development above enhancing understanding of the behavior change process (Michie, Rothman, & Sheeran, 2007).

In summary, the above presented integrative models provided helpful compilations of social-cognitive factors important to behavior change. However, some are too parsimonious (and therefore lack important factors), whereas others are too comprehensive (and therefore impractical), or have not specified causal relationships between their predictors. In the following, a framework is suggested that integrates all of the above-reviewed factors, and causally links them as well.

3.2. A causal framework for behavior change

The model in Figure 3 represents a compilation of the major predictors of health behaviors that can serve as a framework for developing and evaluating behavior change interventions. The model is not proposed as a competitor of the existing health behavior theories. Rather, it aims at providing a synthesis of the reviewed models. This is necessary, so potentially important behavior change processes are not a priori missed (Abraham, 2012). The model therefore aims at being as comprehensive as necessary to inform interventions, but as parsimonious as possible. Furthermore, as an extension of some of the above presented integrative models (e.g. the RANAS), interrelations between the behavioral determinants are indicated, as these will have implications for intervention development (Michie et al., 2007). More concretely, causal relationships between the determinants will further inform about the proximity and thus the theoretical behavior change impact of the factors (cf. Flay et al., 2009), and synergetic behavior change effects of the determinants will be highlighted.

Behavioral determinants

The model proposes three major areas of overlap that were identified in the above review of health behavior theories: outcome expectancies, self-efficacy, and post-motivational factors. These contain the major predictors of health behavior identified in the above review.

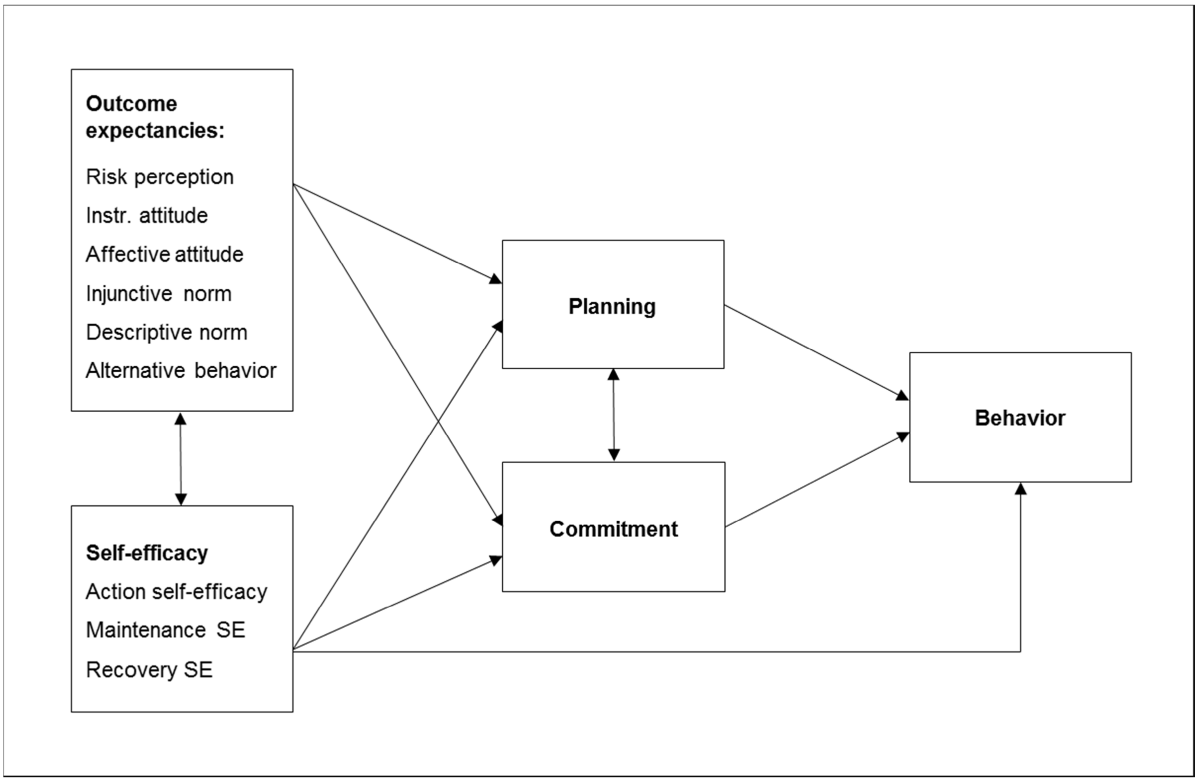

Figure 3. A causal framework for behavior change (SE = self-efficacy).

Outcome expectancies are summarized here as any beliefs about the consequences of the behavior or of not performing the behavior. They are included in most of the above presented theories, but are sometimes labeled differently (e.g. behavioral beliefs in the TPB [Ajzen, 1991], benefits and costs [HBM; Becker et al., 1974], response efficacy [PMT; Rogers, 1983], and severity and vulnerability [HBM and PMT]). Furthermore, it has been suggested to add normative influences to this section (SCT; Bandura, 2001; HAPA; Schwarzer, 2008). Unlike in some models (e.g. HAPA) the factors that classify as outcome expectancies will not be combined to one construct in the present model, but will be considered separately in order to gain maximum information for developing behavior change interventions. The major outcome expectancies specified by the above theories included beliefs about health risks (perceived vulnerability, perceived severity), cost-benefit beliefs (instrumental attitude), anticipated emotional responses (affective attitude), and normative beliefs (injunctive and descriptive norms). Furthermore, it has been suggested to take into account beliefs about alternative behaviors (RANAS, Mosler, 2012; PMT, Rogers, 1983).

Self-efficacy has been consistently found important to behavior change and has been integrated in most theories (SCT, PMT, TTM, HAPA, TPB). As specified in the HAPA (Schwarzer, 2008), considering at least three forms of self-efficacy can be beneficial: action self-efficacy, maintenance self-efficacy, and recovery self-efficacy. As the current framework is a continuum model, the different self-efficacies do not correspond to different phases of behavior change, but may exert their influence at any given position on the behavior change continuum. The differentiation may be advantageous, because more detailed information can be gained, where a person’s confidence is low: the ability to initiate action, cope with barriers, or recover from relapse. The addition of further types of self-efficacy may also be considered if found useful (e.g. as proposed in the I-Change model, de Vries et al., 2005).

Regarding post-motivational factors, one well-researched determinant is **planning** (i.e. implementation intentions, Gollwitzer, 1999; cf. action planning and coping planning, Schwarzer, 2008). Furthermore, **commitment strength** has emerged as an important factor to consider, as it has been shown to be a major mechanism of some effective BCTs (e.g. reminders, Tobias, 2009). The underlying mechanism by which planning and commitment affect behavior is by increasing behavioral accessibility and facilitating remembering. Therefore, adding remembering as a mediator between commitment-behavior and planning-behavior relationships may be considered. For reasons of parsimony, this was not explicitly included in the model, as no additional implications for intervention would be gained (remembering or commitment enhancing effects of interventions cannot be differentiated, cf. Mosler & Tobias, 2007).

Besides the above behavioral determinants, personal, social, and environmental **predisposing factors** should be considered (Flay et al., 2009). These may exert the most distal influences on behavior and will therefore not have strong direct impact on behavior (Flay et al., 2009; Sutton, 2008). However, they are antecedents of the above presented behavioral determinants. Therefore, they may provide additional background information for shaping the contents of the interventions, or aid in refining the items that assess more proximal behavioral determinants. Such factors have been specified in some of the above reviewed theories (e.g. I-Change model, de Vries et al., 2005; TTI, Flay et al., 2009), and may include knowledge (factual and action knowledge, Mosler, 2012), skills (e.g. coping skills, Flay et al., 2009), objective barriers (e.g. broken safe water options), factors influencing elaboration likelihood (Petty, Barden, & Wheeler, 2009), and others more (see Flay et al., 2009).

In discordance with some health behavior theories (e.g. SCT, TPB, PMT, HAPA), behavioral intention is not considered a behavioral determinant in the present model. The crucial role of intentions in many health behavior models has been questioned. Leventhal and Mora (2008), for example raise doubts about the importance of the construct in translating motivation into volition. From a behavior change perspective, while intention may frequently emerge as the strongest behavioral predictor (Conner & Norman, 2005), it is also difficult to directly target in interventions. According to motivational theories, intention can be modified by changing its antecedents: outcome expectancies. In this sense, intention as a behavioral predictor may also be seen as a redundancy in the model that will cover the behavioral impact of outcome expectancies. In conclusion, while statistically more variance in behavior may remain unexplained by omitting intentions, more detailed information for intervention development will be gained.

Behavioral outcomes

The outcome of the present model can be behavior at a point in time or time period, behavior change, or habitual behavior. The latter integrates behavior performance with habit (i.e. automaticity) for the behavior. This has been suggested by several authors (Lally & Gardner, 2011; Tobias, 2009; Verplanken & Wood, 2006), but usually either habit or behavior is considered. Here, similar to Abraham’s (2008) suggestion, habitual behavior is understood as a continuum ranging from no behavior to habitual behavior. Persons at the low end of the continuum exhibit weak habit strength, and only occasional or no behavior performances. Persons at the high end of the scale, in turn, are characterized by strong habits coupled with frequent behavior performance. In the mid-range, people only occasionally perform the behavior but have moderate or strong habits for it (e.g. because they used to exercise often, but do not at the moment), or people who have recently started to perform a new behavior, and are in the process to develop habits for it. The advantage of this continuum is that all individuals in a given population can be described at the same go (versus stage conceptions that require separate analyses per stage, e.g. intenders vs. adopters vs. less habitual actors vs. more habitual actors).

Causal relationships

In the framework, behavior is determined by commitment, self-efficacy, and planning. The direct behavioral effects of self-efficacy and planning was proposed by SCT (Bandura, 2001), implementation intentions research (Gollwitzer, 1999), and the HAPA (Schwarzer, 2008). Commitment strength’s direct effect on behavior is in accordance with Cognitive Dissonance Theory (Festinger, 1957), which assumes that persons are keen to reduce tension states that result from divergent cognitions (e.g. high importance to perform behavior but not performing it; Festinger, 1957). All three proximal determinants have further indirect effects on behavior which are explained below.

Commitment strength assumes the central role in the model. Besides its direct effects on behavior, it can elicit planning (Tobias, 2009), which can be interpreted as an effort to enact intentions, a key characteristic of goal commitment (Nenkov & Gollwitzer, 2012). In addition, a moderating effect on the planning–behavior relation is proposed. This indicates that the behavior change effect of strategic planning is contingent on commitment strength, i.e. low-committed persons are less likely to enact their plans.

Planning, in turn, is assumed to have an effect on commitment strength. In consequence of forming implementation intentions (e.g. due to a request), the person will develop a tension for performing the behavior (i.e. commitment strength), which may be again explained by the discrepancy of consonant (plans to perform the behavior) and dissonant cognitions (not performing the behavior). This, in turn, will urge the individual to act. An example situation when this may occur is a planning intervention, where participants are asked to form implementation intentions.

Self-efficacy, as in SCT and the HAPA, has a further important role in the model. Besides the direct behavioral effect, it is assumed to influence commitment, as well as planning. This corresponds to Bandura's assumption that goals (i.e. antecedents of commitment; Tobias, 2009) are set that are perceived achievable (Bandura, 2001). The effect of self-efficacy on planning, in turn, corresponds with the same effect that is proposed in the HAPA; more self-efficacious persons are more likely to plan (Luszczynska & Schwarzer, 2003; Schwarzer, 2008).

Outcome expectancies are the most distal predictors in the model. In most of the above reviewed theories, outcome expectancies determine intentions, which are antecedents of commitment strength (Tobias, 2009). As intention was omitted here, they therefore directly affect commitment. Furthermore, as specified in the HAPA (Schwarzer, 2008), outcome expectancies affect planning (even though in the HAPA, this effect is mediated by intentions).

In this section, a theoretical framework for deriving theory-based interventions to promote safe water consumption was presented. The framework contains a compilation of the most important predictors from the major health behavior theories. Moreover, the relationships between the behavioral determinants were summarized from the literature, and further interrelations were proposed. The model already provides some information on how to intervene when attempting to change behavior. For example, when attempting to modify commitment, one could intervene on one of its antecedents, e.g. outcome expectancies. However, two crucial questions remain: Which of the proposed behavioral determinants needs to be tackled to render maximal behavior change? And how can these determinants be modified? These issues will be discussed next.

4. Developing theory-based interventions

As outlined in the beginning, three steps are necessary to develop theory-based interventions: identify behavioral determinants of the target behavior, select effective BCTs to change behavior, and link the BCTs to the behavioral determinant. The previous section provided the theoretical framework of possibly influential determinants. In this section, approaches are described, how specific behavioral determinants can be selected to be targeted in interventions. Thereafter, BCTs are mapped on to the behavioral determinants of the framework model.

4.1. Selecting behavioral determinants

The theories reviewed above have different implications for selecting behavioral determinants for intervention. In particular, the approaches vary regarding whether and with what degree of detail the characteristics of the target population are taken into account in the intervention development process.

One size fits all

As discussed above, continuum theories (e.g. TPB; Ajzen, 1991) assume that their behavioral determinants increase the likelihood of people's behavior performance. This implies that behavior change can be promoted by changing any of the behavioral determinants of the model, and that this holds for all individuals (except for "outliers"). Hence, the selection of behavioral determinants for intervention is already inherent in the theory. If it is a causal theory, the most distal antecedents of behavior must be targeted, as they will work their way through behavior change by modifying the more proximal behavioral determinants of the theory (Sutton, 2008). These interventions, however, will have relatively small behavior change impact, as they have relatively small effective variance explained (see Sutton, 2002). Alternatively, one could "jump into the causal chain" (Sutton, 2008, p. 73), and aim at directly altering proximal determinants. Such interventions, although not informed by the models of the causes of the determinant, can still be considered theory-based with regard to its consequences, and are likely to have more behavior change impact (Sutton, 2008).

This approach is very suitable for testing theories by manipulating behavioral determinants. Regarding real-life health promotion, if this approach were successful, it would be the most cost-effective, as the intervention development process is simple and fast (e.g. no prior assessment of population characteristics required). However, this procedure may fail, because some factors may be more important to the behavior and the target population at hand than others.

Adaptation to target behavior and population

This approach differs from the one size fits all approach by taking into account the characteristics of a target behavior and population. To ensure the former, intervention planners first have to carefully compile the behavioral determinants that may be important for a specific behavior and population (Abraham, 2012). On the one hand, this requires considering different theories (as was done in the previous section), as basing interventions on a single is problematic, because it may not contain the determinants relevant to a given problem (Abraham, 2012). Furthermore, research on the particularities of the target behavior and population (e.g. cultural context) are necessary (see the Intervention Mapping Approach; Bartholomew, Parcel, Kok, Gottlieb, & Ferández, 2011).

To determine the most potentially impactful behavioral determinants, their influence on the behavior, and their changeability need to be considered (Abraham, 2012; Bartholomew et al., 2011; Mosler, 2012). This is achieved with an assessment of determinants from the theoretical framework in the target population by a structured survey prior to intervention development (Mosler, 2012). The most potentially impactful determinants for behavior change in a given population are then identified by statistical analyses. This can be done by comparing people who performed or did not perform the behavior at time of assessment (between-group mean comparisons; Mosler, 2012), or by computing measures of association between determinants and the behavior (correlation or regression analysis; e.g. Huber et al., 2012; Mosler et al., 2010). Furthermore, the changeability of the identified determinants can be taken into account. This can be assessed, for example, by analyzing the current distributions of the determinants in the target population (e.g. by analyzing mean values, where low values would indicate high changeability of the determinant), or by preparing matrices of change objectives (Bartholomew et al., 2011).

By considering both theory and population and target behavior characteristics, this intervention development approach is more likely to produce increased effects on behavior change than the one size fits all approach or interventions that do not systematically take into account theory (Abraham, 2012). However, particularities of specific subgroups are not taken into account. This could be done based on the collected data, however, e.g. by using cluster analysis to identify groups of people with different psychological characteristics (e.g. Tobias, Brügger, & Mosler, 2009). Several interventions would consequently be developed and applied to the identified subgroups. This does not alleviate a further criticism of this approach, however, that the prior assessment of behavioral determinants from several theories is extensive and therefore requires much time and resources. Furthermore, even in clustering approaches, characteristics of each individual are not taken into account. This is the focus of tailored interventions.

Tailored interventions

Tailoring is “any combination of strategies and information intended to reach one specific person, based on characteristics that are unique to that person, related to the outcome of interest, and derived from an individual assessment” (Kreuter, Farrell, Olevitch, & Brennan, 2000, p. 277).

Stage tailored interventions

In this approach, interventions are tailored to the individuals’ stage of change. As eluded above, stage theorists assume that persons pass through discrete stages of behavior change and that different behavioral determinants enhance the transitions between the stages. Furthermore, homogeneity for individuals within one stage is assumed (Abraham, 2008), i.e. “one size fits all in one stage”. Consequently, interventions tailored to fit individuals’ present stage of change should allow transition to the next stage, whereas misfit interventions should have nil or even adverse effects (Sutton, 2005). Although seldom stated, this further implies that in order to achieve actual behavior change, several intervention phases would be necessary, depending on the starting stage of the individual: “Before we can motivate people for a health-promoting change, they first need to be aware of a risk for themselves.” (Bartholomew et al., 2011, p. 330). The tool for stage-tailored intervention planning is a method to reliably assess people’s present stage of change. This is best done with a staging algorithm, which contains a small number of questions (usually regarding intentions and behavior; Abraham, 2008) that should allow the unequivocal categorization of people to the stages of the theory (Sutton, 2008).

The advantages of stage-tailored interventions are that they take into account the characteristics of the target population, including some inter-individual variability. Furthermore, staging algorithms allow for a less laborious assessment of baseline characteristics, as the psychological properties for each stage of change are defined by the theory and need not be assessed. It is clear, however, that the advantages of stage-tailored interventions are contingent on prerequisites that have not been accomplished: reliable staging algorithms, clear definitions of and evidence for the predictors of each stage transition (ideally, causally modeled, Sutton, 2005), and superior effects and cost-effectiveness compared to other approaches. A further criticism of stage-tailored interventions is that they usually only use few behavioral determinants for assigning individuals to stages (Abraham, 2012), even though it has been shown that tailored messages were more effective when tailored on more behavioral determinants (Noar, Benac, & Harris, 2007). This was implemented in the following approach.

Menu-based interventions

This is the most idiographic of the approaches. In contrast to stage-tailoring, this method considers many social-cognitive factors, possibly from a compilation of behavioral theories (Abraham, 2008), similarly to adapted interventions. However, menu-based interventions are tailored, i.e. each individual’s characteristics are considered. Therefore, whereas stage-tailoring may lead to, for example, three different interventions (depending on the number of stages of the model), this approach may lead to a menu of as many interventions as behavioral determinants that were considered. In Abraham (2008), for example, these were 11, indicating the increased number of interventions that will need to be developed.

A disadvantage of this approach is the increased effort for developing the great number of interventions required to meet the needs of all participants. Furthermore, while this approach may be rather easily implemented in computer-based interventions, there may be increased logistic difficulties in field settings. In promoter-delivered interventions, for example, the promoter would have to carry the different interventions, not confound the different BCTs, perhaps assess participants’ characteristics on site, successfully deliver the right intervention to the right person etc. The additional costs that increase with the amount of behavioral determinants may not be warranted.

To conclude, neither the one size fits all approach, nor stage-tailoring seem promising for the present research. The former is more apt to test one particular theory, which was not an aim of this thesis. The latter seems unfitting, at least at this point in time, because of the many unresolved issues of stage theories mentioned above. Finally, while the menu-based approach seems promising, additional effort and impracticalities are involved. These should first be shown warranted by cost-effectiveness studies that compare different approaches (e.g. stage-matched vs. mis-matched vs. menu-based vs. not tailored). The best approach at this point of research and for the given setting thus seems the adaptation of the intervention in accordance with the behavior and the target population.

With this, the presentation of the first step of how to develop theory-based interventions has been completed. The following section provides an overview of BCTs linked to the developed theoretical model.

4.2. Linking BCTs with behavioral determinants

Before BCTs for each behavioral determinant of the theoretical framework will be outlined, some current issues of linking BCTs with behavioral determinants are discussed.

State of the art

Regarding research on BCTs, two observations can be made. First, the list of available BCTs is long, and, second, their systematic classification is rare. This makes it difficult to select the appropriate BCT when planning interventions. In theory, every behavioral model should specify techniques that can modify its determinants. This “linking” of behavioral determinants with BCTs is an important step in developing interventions from theory. In reality, such information is mostly absent. A further difficulty is that many interventions are not reported in sufficient detail to allow for identification of the BCTs used or for inferring about the behavioral determinants targeted (Abraham & Michie, 2008). In consequence, interventions cannot be reliably replicated, hampering the development of evidence-based interventions. Two improvements are required to advance the science of behavior change: developing a taxonomy of BCTs, and mapping these BCTs on to behavioral determinants.

A taxonomy of BCTs should ideally comprise standardized definitions of BCTs that all behavior change scientists and practitioners adhere to. This is not the case to date. A start has been made, however, by Abraham and Michie (2008). They wrote standardized descriptions of 26 BCTs and showed that raters using a coding manual were able to reliably detect these BCTs in 195 intervention descriptions (Abraham & Michie, 2008). This work was recently extended to 40 BCTs (Abraham, 2012), that were also categorized regarding their assumed modifiability of 11 behavioral determinants (see Michie et al., 2008 for a description of these).

More researchers have worked on this second task; mapping BCTs on to behavioral determinants (Bartholomew et al., 2011; Lally & Gardner, 2011; Mosler, 2012; Mosler & Tobias, 2007). Mosler and Tobias (2007), for example, based on a synthesis of earlier classifications, grouped a great number of interventions according their mode of operation derived from the MPMH (Tobias, 2009). For example, the defined grouped techniques that persuade or motivate people, i.e. information, argumentative and affective persuasion, and requests (e.g. to perform behavior). While clearly improving earlier systematics by basing BCTs on theory, the classification has some shortcomings. For example, a distinction was made between techniques that are assumed to initiate behavior and techniques that support existing behavioral dispositions, implying a stage conception, which is not proposed by the theory. This distinction led to an overlap between BCTs in different categories that essentially modify the same behavioral determinants. Some requests, for example, were categorized as techniques to motivate (e.g. request to think about behavior), and as techniques to prompt behavior performance (e.g. implementation intentions), although according to theory, they all modify behavior via eliciting tension, and increasing accessibility (Tobias, 2009).

Perhaps the most extensive and elaborate classification attempt in health psychology has been made by Michie et al. (2008), who asked experts to rate 23 BCTs regarding their effectiveness to modify 11 theory-derived behavioral determinants. This resulted in a 23 BCTs x 11 determinants matrix of experts' agreement regarding the mode of operation of the BCTs. This research generated important hypotheses. Now, intervention studies must test whether the BCTs indeed modify the proposed determinants. Such studies need to be strongly based on theory throughout the development and evaluation process, and apply mediation analyses to test the proposed mode of operation of the intervention (Michie & Prestwich, 2010). “The goal of mediation analysis is to establish the extent to which some putative causal variable X [e.g. BCT] influences some outcome Y [e.g. behavior change] through one or more mediator variables [e.g. attitude change].” (Hayes, 2012, p. 1). Prerequisites of good mediation analyses (i.e. improving causal inference) are experimental manipulation of the mediator (Michie & Prestwich, 2010), e.g. by an intervention, and selecting a study design to isolate the mediators (Williams, 2010). The latter can be achieved by selecting an appropriate control group: “For example, intervention research designs that isolate the added effect(s) of theory-based intervention component(s) beyond the effect(s) of other components are likely to yield greater understanding of the underlying theory.” (Williams, 2010, p. 467). Such analyses are rare, but reveal important understanding about the behavior change process (see Albarracín et al., 2005 for a good example).

In the following, BCTs are linked to the behavioral determinants of the theoretical framework of this thesis. The basis for this overview is the list of techniques described in Abraham (2012), as an attempt to adhere to common definitions. In addition, an effort is made to classify interventions according to their theoretical behavior change impact. It is assumed that the more experiential the technique, the stronger the impact on the behavioral determinant and thus on behavior (cf. Knoll et al., 2011). The following classification therefore distinguishes the BCTs regarding their degree of being experiential (or more actively involving the individual; cf. Mosler & Tobias, 2007).

Changing outcome expectancies

As proposed by the theoretical framework, outcome expectancies can be grouped and are assumed to affect behavior via common pathways. Therefore, in principle, the same BCTs can be applied to change them, even though the content of the behavior change intervention will vary depending on which of the outcome expectancies is targeted.

Persuasion aims at changing attitudes (i.e. beliefs or outcome expectancies) by presenting arguments or other outcome-related information (Bohner, 2002). Presenting arguments is one of the lesser experiential techniques (Knoll et al., 2011), and includes Abraham’s (2012) techniques 1-3, 5, 6, and 8-13. For example, likely material consequences may be provided (BCT 2 to change instrumental attitudes), e.g. highlight monetary loss due to disability when suffering from arsenicosis. Or, it may be described how the person may feel when performing the behavior (BCT 6 to alter affective beliefs), e.g. to highlight the good taste of water from arsenic-safe deep tubewells. Or, to change norms, information about others’ behavior (BCT 9 to change descriptive norms) or others’ approval of the recipient’s behavior (BCT 10 to change injunctive norms) may be provided. Note that generally when aiming to apply any persuasive technique, people’s elaboration likelihood and other influence factors on message processing should be taken into account, as this can strongly influence intervention effectiveness (see Petty et al., 2009).

Abraham’s (2012) list only contains a limited number of more experiential BCTs to alter outcome expectancies. These are BCTs 4 (prompt recipients to assess their own risk to change risk perception), and 7 (prompt self-assessment of affective consequences to change affective attitudes). Mosler (2012) further lists talking to others to change instrumental beliefs or public commitment to alter norms. Note that the former is likely to also alter norms, whereas the public commitment should primarily alter commitment (Tobias, 2009).

Enhancing self-efficacy

Various techniques have been designed to promote self-efficacy that vary in their experiential degree; some techniques persuade people of their abilities, whereas other techniques actually change people's abilities (i.e. skills) and thus their self-efficacies. For example, Bandura's (1997) four sources of self-efficacy can be targeted (see above). Of these, emotional arousal (i.e. concluding from one's own emotions on one's abilities) is the weakest, whereas mastery experience (i.e. performing the behavior successfully), corresponding to BCT 20 (Abraham, 2012) is the strongest technique (Knoll et al., 2011), as it is the most experiential. Further less experiential BCTs are Abraham's (2012) BCT 14 (use arguments to bolster self-efficacy, i.e. symbolic experience, Bandura, 1997), and BCT 16 (provide instruction). More experiential are BCTs 15 and 17-23, which include setting graded tasks (BCT 17), or prompting self-monitoring (BCT 22). Finally, the provision of infrastructure (e.g. providing multiple hand pump connections to reduce distance to safe wells) may be important to enhance skills for some behaviors (e.g. Mosler, 2012). This may be a particularly impactful technique when immediate intervention success is required (e.g. in emergency situations). To achieve sustainable behavior change effects, however, it may be more useful to strengthen people's capacity to help themselves, e.g. by providing knowledge, where affordable safe water options can be purchased. This, in turn, should increase people's self-efficacy.

Forming plans and enhancing commitment

As planning and commitment are strongly interrelated, they will be discussed jointly. Both determinants can be modified by changing the above discussed factors. However, they can also be directly modified by interventions that can be summarized as requests (Tobias, 2009).

Detailed planning is of course enhanced by forming implementation intentions for specific goals (BCT 30 for action planning and BCT 21 for coping planning, Abraham, 2012). As assumed by the model, this will consequently elicit commitment. To further strengthen commitment-enhancing effects, the implementation intention may be written down or made public (BCT 31). A less experiential version would be BCT 29 (prompt goal setting), which does not involve planning (but may be elicited consequently through the enhanced commitment). Finally, the least experiential technique to enhance commitment is installing reminders (or prompts), or asking people to install them (BCT 37).

Fostering the development of habitual behavior

Finally, it has been suggested that behavioral outcomes can also directly be targeted. Lally, van Jaarsveld, Potts, & Wardle, (2010) showed that automaticity (i.e. habit) of a behavior develops after an average 66 days when behavior is repeatedly performed in stable contexts. Therefore, interventions that aim at creating sustained behavior change should aim at the antecedents of habit, i.e. enabling repetition of behavior in a stable context (Lally & Gardner, 2011). According to Lally and Gardner (2011), such interventions include social support, self-monitoring, and rewards (BCTs 39 & 40, Abraham, 2012).

Hereby, the explication of the last step of developing theory-based interventions is completed; the BCTs were linked to the behavioral determinants of the proposed theoretical framework. Notably, the BCTs have been categorized to the determinants they are assumed to impact the most. But each technique may also modify further determinants (e.g. Mosler, 2012). This should be tested when investigating the mode of operation of the BCTs, rather than only testing the assumed mediating mechanisms, as it is commonly done (e.g. Albarracín et al., 2005). In the following, the research questions are summarized, where after, the studies conducted within this thesis are described.

5. Objectives and research questions

The overall aim of this thesis is to develop and test theory-based interventions to promote safe water consumption. This will be done at the example of promoting arsenic-safe water consumption in Bangladesh. As discussed earlier, theory-based behavior change comprises the identification of behavioral determinants, linking the impactful determinants to BCTs, and testing the effectiveness and mode of operation of the theory-based interventions. Before this can be done, however, the first step is to gain essential background information on the target behavior and population (Abraham, 2012; Mosler, 2012). In the following, the research questions that were derived from the above literature review are summarized according to these four steps.

5.1. Gaining knowledge about the target behavior and population

The first step towards developing interventions for a novel behavior is to gain understanding about the extent and the constituents of the target behavior. This requires a thorough assessment of the target behavior in the population of interest. For arsenic-safe water consumption in Bangladesh this is a particularly vast task, because of the many different types of safe water options implemented. Ideally, such an analysis would yield detailed information regarding the current acceptance and use of every safe water option. This was aimed at in Chapter II. The research questions are:

(1) To what extent are available safe water options actually used by people in contaminated areas?

(2) Which safe water options are more accepted than others regarding psychological factors, both for users and non-users?

The results of this investigation will deliver important information, how the use of each arsenic-safe water option may be promoted. Furthermore, it will have implications regarding which water options should be prioritized by institutions that implement new safe water options in Bangladesh. Finally, the data on the use of the options will allow estimating how many people in Bangladesh may actually be at risk of drinking arsenic-contaminated water, even though they have access to a safe water alternative.

5.2. Identifying determinants of arsenic-safe water consumption

Whereas Chapter II will provide detailed information on each arsenic-safe water option, Chapter III aims at creating a general model to explain the sustainable use of all arsenic-safe water options. In this regard, these questions are of interest:

(3) Which factors are related to the habitual use of arsenic-safe water options?

(4) How well does this general model predict the use of specific water options?

With regards to theory-development, the comparison of several behaviors (i.e. arsenic-safe water options) in one study provides a rare opportunity to test the generalizability of a model. The results of this study will thus provide strong evidence on the importance of the behavioral determinants from the above theoretical framework to explain arsenic-safe water consumption. But such a generalizable model also offers practical advantages. While the results of Chapter II will provide very detailed information regarding the investigated options, the model developed in Chapter III, if it proves generalizable, could also be applied to water options that were not included in the study. Thereby, it could serve as a tool for developing interventions that can promote any of the investigated, and even emerging safe water technologies.

Further insights on the determinants of safe water consumption can also be gained from Chapters IV and V. The research questions of interest in this regard are:

(5) Which behavioral determinants can explain the use of neighboring arsenic-safe wells? (Chapter IV).

(6) Can factors from the TPB and commitment strength predict switching to arsenic-safe deep tubewells? (Chapter V).

In this regard, Chapter V will be particularly revealing as the investigation was longitudinal and experimental.

5.3. Developing and testing theory-based interventions

In the next step, theory-based interventions to promote arsenic-safe water consumption will be developed and tested. In Chapter IV, the behavioral determinants of the theoretical framework are first assessed and their improvement potential to promote switching to arsenic-safe wells will be ascertained. The research question is:

(7) Which behavioral determinants have the greatest improvement potentials to promote switching to arsenic-safe wells?

The results of this research question will provide insights, how behavioral determinants can be derived from theory, assessed in the target population, how improvement potentials of the determinants can be identified, and, lastly, how theory can be used to derive BCTs corresponding to the identified determinants.

Thereafter, the effects of the theory-based interventions in addition to an informational intervention will be compared to an information-only comparison condition. This analysis shall answer this question:

(8) Do theory-based BCTs increase behavior change effects of informational interventions?

This research question will also be addressed in Chapter V, but for a different arsenic-safe water option, allowing further generalizability of a possible effect.

5.4. Investigating the mechanisms of theory-based interventions

In the final empirical chapter of this thesis, Chapter V, the mode of operation of theory-based interventions is investigated. It is assumed that the in Chapter IV developed interventions (reminders, implementation intentions, and public commitment) promote behavior change by increasing commitment strength. The research question is:

(9) Do the theory-based additions to an informational intervention increase switching to arsenic-safe wells by changing commitment strength?

The results of this investigation will provide evidence whether reminders, implementation intentions, and public commitment indeed change behavior by changing commitment strength. If this is indicated, this will support the assumption of some of the reviewed theories (e.g. MPMH; Tobias, 2009) that commitment strength is an important factor in the behavior change process.

In the next and final section of this chapter, the studies that were conducted to investigate these research questions are described.

6. Description of the studies

Three empirical studies were conducted to develop and test theory-based interventions to promote safe water consumption. All were conducted in Bangladesh (see Figure 4 for the overall timeline of the studies).

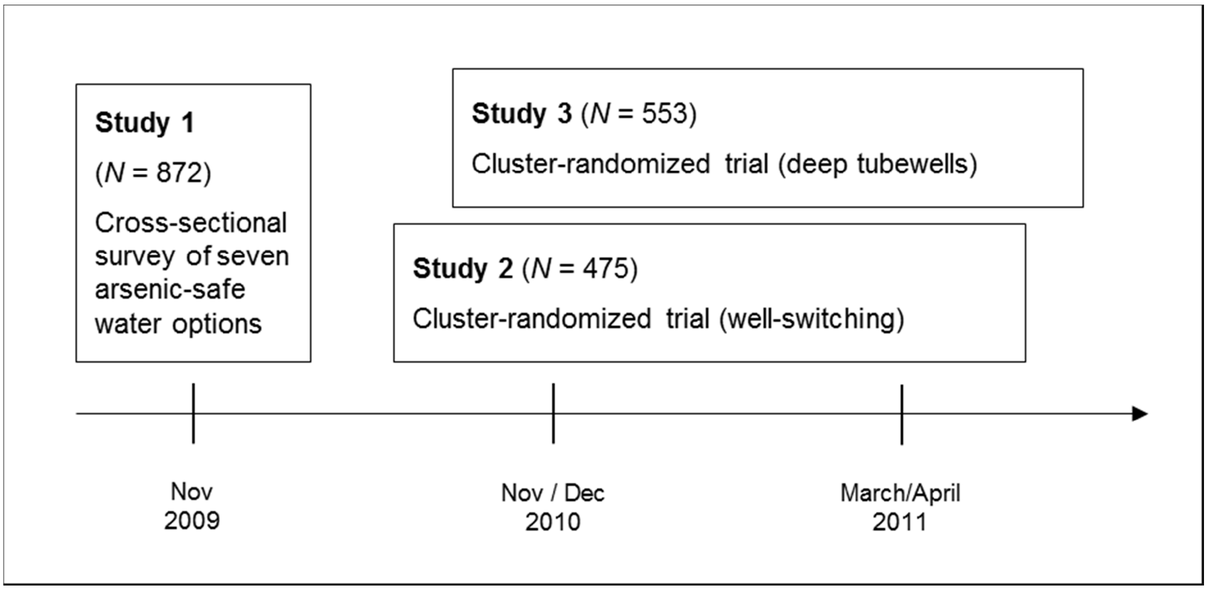

Figure 4. Overview of research timeline.

6.1. Study designs

Study 1 was a large-scale cross-sectional survey that assessed the use of and social cognitions about seven arsenic-safe water options currently implemented in Bangladesh. It served as the data base for the investigations conducted in Chapters II[1] and III.

Study 2 (Chapter IV) and **Study 3** (Chapter V) were part of two research projects that employed the same longitudinal, field-experimental designs (see Figure 5), but investigated different arsenic-safe water options. Study 2 investigated the promotion of well-switching (i.e. switching to neighboring arsenic-safe wells), and Study 3 targeted the use of arsenic-safe deep tubewells.

As can be seen in Figure 5, both studies are excerpts from longer trials that contained a further intervention phase, and a panel measure after a 6-months phase of inactivity (the results are in preparation and will be published elsewhere).

[1] Note that the baseline assessment of Study 3 (users vs. non-users of deep tubewells) was also integrated to the analysis of arsenic-safe water options provided in Chapter II, because deep tubewells had not been surveyed in Study 1 (see Chapter II for details).

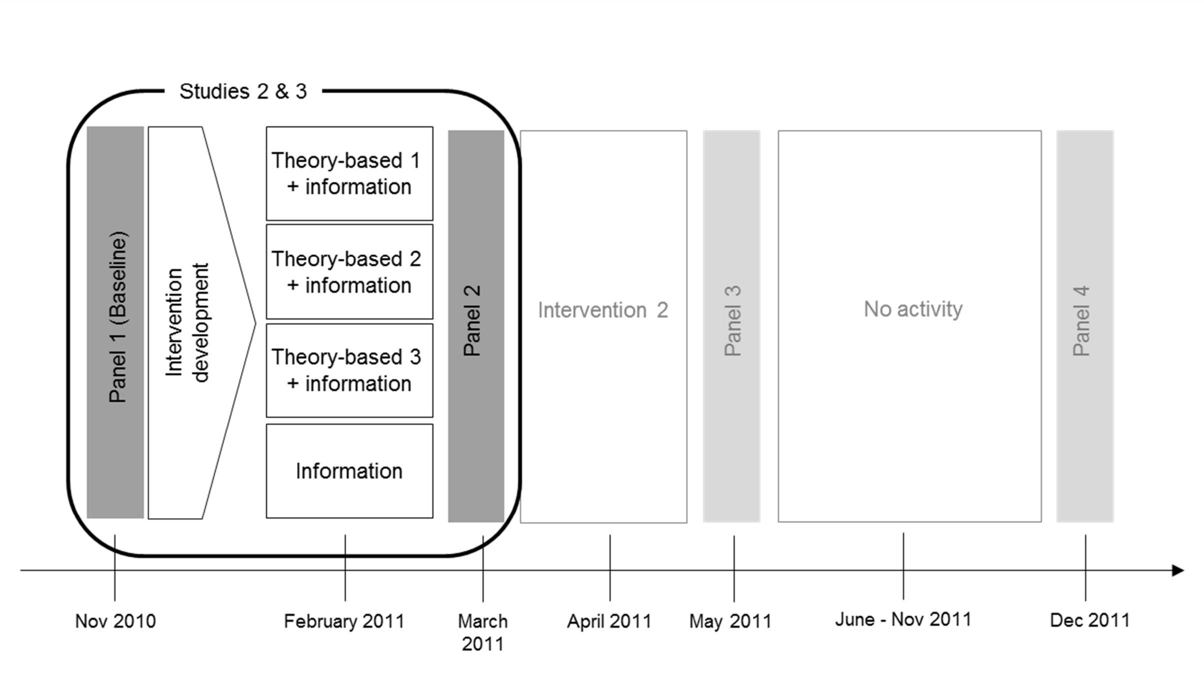

Figure 5. Basic design of the cluster-randomized trials conducted in Studies 2 and 3.

A baseline survey and an intervention development phase preceded the trials. The baseline assessments included a random selection of users and non-users of neighboring arsenic-safe wells (i.e. well-switching, Study 2), and of arsenic-safe deep tubewells (Study 3), similarly to Study 1. This allowed for cross-sectional analyses of the behavioral determinants of using arsenic-safe wells. From these results, theory-based interventions were derived (see Chapter IV for the development process in Study 2), that were then tested in the cluster-randomized trials (Chapters IV and V).
In both studies, following Williams' (2010) recommendations for testing theory-based interventions, a commonly applied promoter-delivered informational intervention was compared to three theory-based intervention conditions. These combined information with additional theory-based BCTs that were developed from the baseline results (see Chapter IV, and Appendix III for intervention materials[2]).

The cluster-based design was chosen to avoid information contamination; people in Bangladesh live close together, and some of the applied interventions were public. In each study, seven clusters of two to five villages each were randomly allocated to one of the four conditions by random number generation. For the cluster-randomized trials, users of arsenic-safe wells at baseline were excluded. The baseline sample sizes for

[2] Intervention manuals are available on request.

the trials were therefore smaller than the overall sample sizes (Study 2: $n = 370$; Study 3: $n = 340$).

6.2. Ethical conduct

All studies were conducted in strict compliance of the ethical guidelines of the American Psychological Association (APA), the Declaration of Helsinki, the ETH Zurich, and the ethics review guidelines of the University of Zurich, Switzerland. At the end of the studies (after the last survey), participants of the cluster-randomized trials (Study 2 and Study 3) who had not been assigned to the most effective intervention condition received a further visit by the health promoter, who offered to provide the most effective behavior change intervention to these household. At the recommendation of our local advisors, no incentives were delivered.

6.3. Local partners

Prior to Study 1, collaboration with local agencies involved in arsenic mitigation was sought. The key collaborator was Md. Mojahidul Hossain, a local sociologist. He played a crucial role at every step of study implementation, most importantly perhaps by facilitating communication between the researchers, local organizations, and staff.

Furthermore, several organizations provided assistance in the studies (see acknowledgement sections in Chapters II-V). In particular, the Department of Public Health Engineering (DPHE) of the GoB, and UNICEF Bangladesh provided helpful assistance throughout this research, especially for study site selection, and contacting NGO and governmental organizations at the sites for assistance. Permission to conduct the surveys was obtained from all local government entities prior to the surveys and interventions.

The collaboration further allowed for transferring the present findings into practice. Several presentations regarding the outcomes of the study were held at the organizations during the research, and some of the results informed UNICEF Bangladesh’s current arsenic mitigation campaign.

6.4. Study sites

All studies were conducted in rural areas of Bangladesh, because cities are mostly unaffected by arsenic contamination. In Study 1, surveys were conducted in 40 villages of six districts in Bangladesh. These included Munshiganj district, which is located near Dhaka, the capital of Bangladesh, Comilla district (South-East of Dahaka), and Brahmanbaria district located in the East of Dhaka. Furthermore, three coastal districts of Bangladesh were surveyed: Satkhira, Bagerhat, and Khulna. See Chapters II and III for details on study sites selection procedures.

Study 2 was conducted in 16 villages of Shivalaya and Harirampur subdistricts of Manikganj, which is located approximately two hours West of Dhaka by bus. This area exhibits medium arsenic-contamination density and is therefore suitable for well-switching, as enough arsenic-safe wells are available for sharing. Only few other arsenic-safe water options in this area were found, indicating that this region, perhaps due to generally low-density of contaminated wells, has not recently been prioritized in agencies' mitigation efforts.

Study 3 was conducted in 15 villages of Monoharganj, subdistrict of Comilla, approximately six hours South-East of Dhaka by bus. In contrast to Manikganj, almost 100% of wells in Monoharganj are contaminated with arsenic. Well-switching is therefore not feasible, and arsenic-safe alternatives are the only option. Besides the high density contamination, arsenic concentrations of groundwater are exceptionally high. Therefore, this area has recently received more attention and aid resources. During the time of the present study an intervention by UNICEF Bangladesh and VERC (Village Education Resource Center) was being conducted in some villages of Monoharganj. The villages of Study 3, however, were geographically separate from that project, and no new deep tubewells were installed before or during the study.

6.5. Participant selection

In all studies, participants were randomly selected by random route method (Hoffmeyer-Zlotnik, 2003). In this method interviewers walk in opposite directions and interview every given number of households (e.g. every third). Sampling procedures were complicated by the spatial heterogeneity of arsenic contamination. Depending on the density of arsenic contamination in a given study area, this lead to a varying proportion of contacted households who did not meet the first of our two inclusion criteria: (1) Be at risk of drinking arsenic-contaminated water (assessed by self-report); and (2) have access to an available safe water option (ensured by purposive village selection). Whereas in Study 1, people who owned or mainly drank from untested tubewells (categorized as reportedly being at risk), Study 2 and 3 only included persons who drank from arsenic-contaminated wells at baseline, which lead to a further exclusion of households.

6.6. Data collection

All data were collected by face-to-face interviews which were conducted in Bangla, the local language. Between eight to 12 professional Bangladeshi interviewers were recruited for each of survey round. Interviewers were men and women during Study 1, but only women were selected for Studies 2 and 3, as it was discovered that women in some areas of Bangladesh feel uncomfortable to communicate with unknown men.

Before each survey, interviewers were thoroughly trained (see Chapters II-V for details). The participants were inhabitants of rural areas, where many people, particularly women, are not able to read or write, and nobody is accustomed to answering psychological questions. Therefore, particular care was devoted so that all staff members attained the same vocabulary to ask the questions and present the answer categories. Furthermore, examples were specified, how to explain the questions in more figurative detail.

Oral informed consent was obtained at each interview, and participants were assured that they could withdraw participation at any time during the course of the study. The interview duration therefore varied, but was approximately 1 - 1.5 hours. With few exceptions (see Chapters II and III), there was very little refusal.

6.7. Questionnaire

A questionnaire was specifically constructed during this thesis (see Appendix I for an English version). The first version of the questionnaire was developed in collaboration with Alexandra C. Huber, a fellow PhD candidate who studied the promotion of fluoride-free water consumption in Ethiopia, and Dr. Robert Tobias. A large item pool was compiled from the published literature that enabled the assessment of all the constructs from the theoretical framework, as well as water related particularities (e.g. well ownership), and sociodemographic variables. All item and answer category wordings were then adapted to the behavioral and the local context of Bangladesh. Furthermore, several open-ended questions were included (e.g. about the advantages and the disadvantages of several water options). Besides providing valuable information for intervention development, the answers to these questions allowed for further refinement of some structured items in subsequent studies. The questionnaire was thoroughly translated and pretested (see e.g. Chapters II and III for more details). Finally, to obtain multi-item measures, exploratory factor analyses were conducted. The results indicated that items largely corresponded to the hypothesized factors, but some items with high loadings on different factors were subsequently excluded.

With this, the general introduction and overview of this thesis concludes. In the following, Chapters II – V will present the empirical studies that were conducted to answer the above described research questions.

Chapter II

Acceptance and use of eight arsenic-safe drinking water options in Bangladesh

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A similar version of this chapter is

submitted for publication

(Inauen et al., submitted)

Abstract

Arsenic contamination of drinking water is a serious public health threat. In Bangladesh, eight major safe water options provide an alternative to contaminated shallow tubewells. However, it is uncertain how well these options are accepted and used by the population at risk. Based on the RANAS model (risk, attitudes, norms, ability, and self-regulation) this study aimed to identify the acceptance and use of available safe water options. Face-to-face interviews were used to survey 1,268 households in Bangladesh. The questionnaire assessed water consumption, acceptance factors from the RANAS model, and socioeconomic factors. Although all respondents had access to at least one arsenic-safe drinking water option, only 62.1% of participants were currently using these alternatives. The most regularly used options were household arsenic removal filters (92.9%) and piped water supply (85.6%). The least used option was household rainwater harvesting (36.6%). Those who reported not using an arsenic-safe source differed in terms of numerous acceptance factors from those who reported using arsenic-safe sources: non-users were characterized by greater vulnerability; showed less preference for the taste and temperature of alternative sources; found collecting safe water quite time-consuming; had lower levels of social norms, self-efficacy, and coping planning; and demonstrated lower levels of commitment to collecting safe water. Acceptance was particularly high for piped water supplies and deep tubewells, whereas dug wells and well-sharing were the least accepted sources. Intervention strategies were derived from the results in order to increase the acceptance and use of each arsenic-safe water option.

Keywords: arsenic mitigation; safe water consumption behavior; acceptance; risk beliefs; attitudes; norms; self-efficacy; self-regulation; developing country; Bangladesh

Introduction

Arsenic contamination of drinking water resources is being increasingly recognized as a global health problem. The chronic ingestion of even low levels of arsenic has been linked to internal cancers (Smith & Steinmaus, 2009) and elevated mortality rates from myocardial infarction (Yuan et al., 2007), along with numerous other health problems. Nowhere is the problem more serious than in Bangladesh. Arsenic exposure has been estimated to account for 21% of all-cause mortality in one moderately contaminated sub-district of Bangladesh (Argos et al., 2010) and for 42,700 to 56,400 deaths per year nation-wide (Flanagan, Johnston, & Zheng, 2012).

The arsenic problem was first recognized in the 1990s. That was when a national survey showed that approximately 27% of shallow tubewells exceeded Bangladesh’s permissible limit of 50 µg/L, while 46% exceeded the WHO’s provisional guideline value of 10 µg/L (DPHE, BGS, & MML, 2000). Cities and municipalities, for the most part, supply water from deep, arsenic-free aquifers, but in rural and peri-urban areas, shallow, privately-owned tubewells are the principal sources of drinking-water. Early mitigation efforts focused on raising awareness of the risks posed by arsenic, which was a daunting challenge because arsenic has no taste or odor and symptoms take years to develop. Basic information was imparted to villagers during a massive tubewell screening campaign from 2000 to 2006 in which nearly 5 million wells in arsenic-prone areas were tested and painted red or green, depending on they were over or within the national standards (Johnston & Sarker, 2007).

Subsequent efforts focused on the promotion and installation of alternative arsenic-free water sources. The National Arsenic Mitigation Policy recommends that wherever feasible, piped water systems should be promoted and that preference be given to surface water over groundwater sources (GoB, 2004a). The implementation plan accompanying the policy endorsed the promotion of various alternative drinking water sources in arsenic-affected areas: dug wells and pond sand filters were to be given priority, and deep tubewells installed only as a last resort. Piped water supply systems were identified as the long-term goal. Other endorsed alternatives included large-scale surface water treatment plants, rainwater harvesting systems, and household or community arsenic removal technologies (GoB, 2004b). The technical suitability of these alternatives depends on local hydrogeologic and geographic conditions, so different options are promoted in different zones of the country.

The local-scale spatial distribution of arsenic is highly variable (van Geen, 2003), and in many affected villages, there are enough safe shallow tubewells to supply the entire population (van Geen et al., 2002). Although the policy and implementation plan do not explicitly refer to the sharing of safe, shallow tubewells, well-sharing (sometimes referred to as well-switching) was a key message in the tubewell screening program.

By 2006, it was estimated that more than 100,000 alternative sources had been installed in arsenic-affected areas. In spite of the stated policy preference for surface water, 70% of new installations were deep tubewells (Kabir & Howard, 2007). Experiences from localized studies showed that well-sharing was also common in some areas (Johnston & Sarker, 2007; Opar et al., 2007). By 2006, an expert review estimated that that 29% of the population initially exposed to arsenic had switched to arsenic-safe shallow tubewells and that another 12% had switched to deep tubewells (Ahmed et al., 2006). The use of the other alternative sources was considered negligible.

However, the allure of the arsenic-contaminated shallow tubewells is strong, especially as memories of the well-screening survey fade, and there is a lack of data about long-term water use practices. All alternative options involve more time or effort, and the collection of water from a community source is a very different behavior than the use of one’s own private tubewell. Operation and maintenance may be more complicated, and community-level management can be erratic. In a survey of 1,000 arsenic-safe water sources, Kabir found 10% of deep tubewells, nearly a quarter of dug wells and pond sand filters, one-third of rainwater harvesting systems, and 83% of arsenic removal technologies to be non-functional (Kabir & Howard, 2007). However, this review focused on technical performance, and little information is available regarding end-user acceptance or factors influencing families to use or not use arsenic-safe water sources. Another study of deep tubewell use in Sreenagar, Bangladesh used psychological analysis derived from the Protection Motivation Theory to show that social factors were much more important determinants of water source usage than knowledge and awareness of arsenic or perceived arsenic vulnerability and severity (Mosler et al., 2010).

The aim of the present study is to provide an update on the use of available arsenic-safe water options and to investigate social and psychological factors of acceptance contributing to water use practices. We address two main questions:

(1) To what extent are available safe water options actually used by people in contaminated areas?

(2) Which safe water options are more accepted than others regarding psychological factors, both for users and non-users?

We investigate the following alternative water supplies: dug wells, pond sand filters, deep tubewells, piped water supply, household and community arsenic removal technologies, household rainwater harvesting systems, and well-sharing. We use the term acceptance as a comprehensive construct to describe positive values in psychological factors that are influencing the use of a certain option. High acceptance means that this option has high values in several psychological factors.

To determine the behavioral factors influencing the use of an option, we drew on the RANAS model (Mosler, 2012). In this model, psychological factors are ordered in five different blocks: Risk, Attitudinal, Normative, Ability, and Self-regulation factors. These blocks are comprised of several psychological factors, which provide a complete representation of the possible drivers of health behavior change (Albarracín et al., 2005). The factors, their meanings, and their assessments are described in Table 1.

In the present study, we focus on the differences between the options regarding these factors in order to understand why some options are more accepted than others and to determine which factors have to be especially taken into account when introducing a certain option.

The main goal of our analysis is to improve the sustainable use of arsenic-safe water options by supplying psychological data that show the different aspects of the acceptance of these options. If several options are technically equivalent, then the most accepted option should be installed because it will be the most preferred and used. If, because of technical, financial, or institutional reasons, only one single option can be realized, then our analysis provides evidence regarding the factors that should be tackled in order to improve acceptance and use.

Table 1. *Psychological factors and their assessment*

Psychological factors	Definition	Assessment question
Risk factors		
Perceived vulnerability	A person's subjective perception of his/her risk of contracting arsenicosis	"How high or low do you feel are the chances that you get arsenicosis?" (-4 = very low to 4 = very high)
Perceived severity	A person's perception of the seriousness of the consequences of contracting arsenicosis	"Imagine that you contracted arsenicosis, how severe would be the impact on your life in general?" (0 = not at all severe to 4 = very severe)
Factual knowledge	An understanding of how a person could become affected by arsenic	2009: Seven items assessed factual knowledge. Respondents were asked to describe what arsenic is, to name the effects that arsenic can have on the body, to name causes of the effects of arsenic on the body, and to give an estimate how long it takes for arsenic to take effect on the body. Three further questions asked whether arsenic was contained in water from red (i.e., arsenic-contaminated) tubewells or in food cooked with that water and if water from the arsenic-safe option the respondents used was free of arsenic. 2010: 14 questions asked about which water sources contained arsenic, whether contaminated water was safe to drink, which medical conditions could be caused by arsenic, and for which tasks it was okay to use arsenic-contaminated water. (0 = no knowledge to 4 = maximum knowledge)
Attitude factors		
Instrumental beliefs	How time-consuming is collection	"Do you think that collecting water from arsenic-safe option is time consuming?" (0 = not at all time consuming to 4 = very time consuming).
Affective beliefs	Taste and temperature	"How much do you like or dislike the taste (temperature) of the water from the arsenic-safe water option?" (- 4 = dislike it very much to 4 = like it very much).

Normative factors		
Descriptive norm	Perceptions of which behaviors are typically performed	"How many people outside your family collect water from arsenic-safe option?" (0 = almost nobody to 4 = almost everybody)
Injunctive norm	Perceptions of which behaviors are typically approved or disapproved of by important others	"You drink water from the arsenic-safe option. Do people who are important to you rather approve or disapprove of this?" (-4 = they disapprove very much to 4 = they approve very much)
Ability factors		
Self-efficacy	The belief in one's capabilities to organize and execute the course of actions required to manage prospective situations	"How sure are you that you can collect as much water from the arsenic-safe option as you need?" (0 = not at all sure to 4 = very sure)
Action knowledge	Knowing how to perform the behavior	2009: Participants were asked to describe how arsenic and its harmful effects can be avoided, and to name as many arsenic-safe water options as they knew. 2010: Respondents were asked whether they knew the location of a safe water option in their village, whether it was safe to drink from a green-colored tubewell, whether arsenic can be removed by boiling, and to name water sources that are free from arsenic
Self-regulation factors		
Coping planning	How the person plans to cope with distractions and barriers	"Have you made a detailed plan regarding what to do when the arsenic-safe water option gets broken?" (0 = no detailed plan at all to 4 = very detailed plan)
Remembering	The behavior needs to be remembered at critical moments	"How often does it happen that you forget to go to collect water from the arsenic-safe option?" (0 = almost never to 4 = almost always)
Commitment	How committed the person is to the new behavior	"Do you feel committed to collect water from the arsenic-safe option?" (0 = not at all to 4 = very much)

Methods

Participants and procedures

Data were collected during two cross-sectional surveys in rural Bangladesh, with a total sample size of 1’268 households. In November 2009, a large survey (N = 872) was conducted in six districts of Bangladesh: Satkhira, Khulna, Bagerhat, Comilla, Munshiganj, and Brahmanbaria. These districts were selected due to their high levels of average arsenic contamination. In all of our study locations, people had access to one of seven arsenic-safe water options: dug wells, pond sand filters, piped water supply, household arsenic removal filters, community arsenic removal filters, household rainwater harvesting, and well-sharing. Due to hydrogeological or geographic conditions, in most of these areas, only one or two alternative options were actively promoted. The second study was conducted in the Comilla district in December 2010, where interviewees had access to arsenic-safe deep tubewells (N = 396). Participants in both studies were exposed to the risk of drinking arsenic-contaminated water (i.e., they either owned an arsenic-contaminated tubewell or collected water from one) and had access to an arsenic-safe water option.

The survey was carried out by professional Bangladeshi interviewers. Conducting structured psychological surveys in rural areas of developing countries is always a challenge. We therefore devoted much time and effort to interviewer training, including extensive rehearsals of interviewing techniques and how to convey knowledge regarding arsenic contamination, arsenic-safe water options, and basic health-behavior theory. Quality control was ensured by the first and the second author, a master’s student, and two local supervisors.

In the villages, interviewers selected households by random-route sampling (Hoffmeyer-Zlotnik, 2003). Interviewers first screened whether the household met inclusion criteria. The participants were the persons responsible for water collection for the selected households. After receiving informed consent, interviewers then conducted structured interviews regarding the arsenic-safe water options that the participants had access to. The interview durations ranged from one to 1.5 hours. The rate of refusal was low, which is quite common for research in developing countries (e.g. Mosler et al., 2010), with the exception of household arsenic removal filter owners: 30% of the approached households with arsenic removal filters declined to participate.

Ethics statement

This study was conducted in strict compliance with the ethical principles of the American Psychological Association (APA) and the

Declaration of Helsinki. It underlies the ethics review board of the ETH, Swiss Federal Institute of Technology Zurich. This review board exempts survey studies that do not comprise an intervention from obtaining ethical approval: “Alle Forschungsuntersuchungen am Menschen … müssen vor Versuchsbeginn durch die Ethikkommission der ETH Zürich beurteilt werden … Reine Befragungen im Sinne von Meinungsumfragen sind keine Forschungsuntersuchungen am Menschen [All research projects involving human participants … must be reviewed by the ethics review board of the ETH Zürich prior to commencement … Pure survey research, i.e. opinion surveys are not considered as research involving human participants].” (http://www.vpf.ethz.ch/about/commissions/EK).

Oral informed consent was obtained from all study participants (written consent was not obtained due to the high rate of illiteracy). Whenever a selected household refused to participate in the study, the interview was ended immediately. The number of refusing households was marked in a dedicated space in the questionnaire of the next consenting household. The regulations of the ethics review board of the ETH allow for either oral or written consent without preference for either form.

Measures

A structured questionnaire was specifically developed for this study. The questionnaire was translated into Bengali and then back-translated into English to verify the quality of the translation. During the questionnaire preparation and pretesting, we worked closely with local collaborators, who advised us regarding how to formulate the questions and answers in the way that participants could best understand.

Water consumption was assessed by asking people how many vessels of which water option and in total they collected for drinking on a typical day. Questions used to assess the psychological factors are described in Table 1. Most factors were scored on a 0 to 4 scale, representing the minimum and maximum possible values. Factors that could have negative as well as positive impacts (e.g., “how much do you dislike or like the taste of water?”) were scored on a scale of -4 to 4.

In most cases, a single question was used to quantify each factor, but ‘factual knowledge’ and ‘action knowledge’ were both determined through a series of questions. In the 2009 survey, knowledge was assessed through open-ended questions; for the 2010 survey, closed-ended questions were used. Each correct answer was assigned one point. This was transformed into the value range of the other variables to standardize the ranges (0 = no knowledge to 4 = maximum knowledge).

In addition, open questions were asked in order to provide a more detailed insight into people's beliefs. Regarding vulnerability, participants were asked why they felt vulnerable to developing arsenicosis or not. Furthermore, answers to open questions about the advantages and disadvantages of collecting water from the arsenic-safe water options and whether there were any seasonal peculiarities in collecting water from the safe option, provided a deeper understanding of what people liked or disliked about water taste and temperature.

Furthermore, socio-demographic parameters were assessed: gender, literacy, religion, age, number of people living in the household, household income, and years of formal education. Finally, respondents were asked whether and how much money their household had contributed to installing the arsenic-safe water option and how much they paid to use it per month.

Data analysis

Data were analyzed using SPSS 18.0. For scaled items, means and standard deviations were computed separately for non-users and users for each of the arsenic-safe water options. For dichotomous items, percentages were calculated. To investigate which arsenic-safe water options were rated high or low regarding each study variable, the frequencies of each arsenic-safe option were compared to the overall mean and the overall frequencies of the entire sample by one-sample t-tests and Pearson χ^2 tests, respectively. Finally, non-users and users for the entire sample were compared regarding all study variables with independent-sample t-tests.

Results

The characteristics of the study participants can be found in Tables 2 and 3. Note that bolded values are significantly higher, and italicized values are significantly lower than the values of the overall sample ($p < .05$).

Use of arsenic-safe water options

Overall, nearly two-thirds of households (62.1%) were using the available arsenic-safe water options for drinking at the time of the survey (Table 2). The most used options were household arsenic removal filters, piped water supply, community arsenic removal, and well-sharing. In contrast, deep tubewells, pond sand filters, and dug wells were used by approximately half of people who had access to these options. Finally, only one third of households used available rainwater harvesters.

Table 2. *Numbers and proportions of users and non-users of the available arsenic-safe water option*

		Overall[1]		Piped water supply		Deep tubewells		Pond sand filters		Community arsenic-removal		Dug wells		Well-sharing		Rainwater harvesting		Household arsenic-removal	
		N	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*N*	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*
Number of users and non-users of the arsenic-safe water option	Non-users	480	37.9[2]	18	*14.4**	182	**46.0***	60	**48.4***	33	*26.4**	64	**51.6***	36	*28.8**	78	**63.4***	9	*7.1**
	Users	788	62.1[2]	107	**85.6***	214	*54.0**	64	*51.6**	92	**73.6***	60	*48.4**	89	**71.2***	45	*36.6**	117	**92.9***
Households paid for installing the arsenic-safe option (% yes)[3]	Non-users	75	15.6*	4	22.2	5	*2.8**	0	*0.0**	1	*3.0**	4	*6.3**	0	*0.0**	55	**73.3***	6	**100***
	Users	346	43.9*	70	**65.4***	73	*36.5**	11	*17.2**	14	*15.2**	25	41.7	0	*0.0**	36	**81.8***	117	**100***
Households that pay to use the arsenic-safe option (% yes)	Non-users	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Users	197	25.0	104	**97.2***	2	*0.9**	5	*7.8**	83	**90.2***	3	*5.0**	0	*0.0**	0	*0.0**	0	*0.0**
Gender (% female)	Non-users	382	79.6	15	83.3*	180	98.9*	40	66.7*	24	72.7	39	60.9*	21	58.3*	54	69.2*	9	100*
	Users	626	79.4	79	73.8	210	**98.1***	43	*67.2**	63	*68.5**	43	71.7	59	*66.3**	35	77.8	94	80.3
Literacy rate	Non-users	317	66.0	6	*33.3**	140	**76.9***	36	60.0	13	*39.4**	41	64.1	22	62.9	53	67.9	6	66.7
	Users	526	66.8	68	65.4	151	70.6	45	73.8	56	63.6	36	61.0	64	73.6	36	81.8	70	61.4
Religion (% muslim[4])	Non-users	457	95.2*	18	100.0	180	**98.9***	47	*78.3**	33	100.0	64	100.0	36	100.0	74	94.9	5	*55.6**
	Users	705	89.5*	107	**100.0***	200	93.5	39	*60.9**	79	85.9	56	93.3	83	93.3	38	84.4	103	88.0

Note. Comparisons between each option and the overall sample: **Bolded values** are significantly greater than the overall frequencies. *Italicized values* are significantly lower than the overall frequencies.

[1]Chi-Square and T-Tests between users and non-users were computed.

[2]One-dimensional Chi-Square test (Null hypothesis: Equal count of users and non-users): $p < .001$.

[3]Due to missing responses, valid percents are reported. Some participants did not know whether their household had paid to install the safe option.

[4]All other participants reported Hinduism as their religion.

* $p < .05$.

Table 3. *Demographic characteristics of participants by users and non-users of the available arsenic-safe water option*

		Overall[1]		Piped water supply		Deep tubewells		Pond sand filters		Community arsenic-removal		Dug wells		Well-sharing		Rainwater harvesting		Household arsenic-removal	
		M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Age	Non-users	37.5	12.8	39.9	10.5	36.3	13.0	40.7	14.4	38.3	12.7	36.0	11.9	*32.9**	11.2	**40.3***	12.4	35.3	12.4
	Users	36.8	12.3	38.9	14.0	35.6	11.7	38.3	12.2	36.3	11.9	36.4	11.7	36.1	12.0	**40.2***	10.6	36.3	12.9
No. of people living in household	Non-users	5.4	2.3	5.1	1.9	5.6	2.5	5.1	2.1	5.8	2.8	5.1	1.9	5.6	2.5	5.3	1.9	6.1	2.8
	Users	5.5	2.3	5.6	2.1	5.7	2.3	5.6	2.5	5.2	2.4	5.5	2.3	5.3	2.4	*4.9**	1.6	5.8	2.2
Monthly income (BDT)	Non-users	8935	8352	12647	13214	10939*	8986	5360*	2841	6317*	4782	4961*	2985	5450*	3291	12355*	10969	8833	5303
	Users	9648	7840	**11931***	9007	**11480***	8879	*7373**	5435	*7439**	5959	*6837**	4494	*7439**	4542	**12237***	6403	9207	9019
Education (years)	Non-users	5.0	4.1	2.1*	3.3	5.7*	3.7	4.6	4.6	2.6*	3.2	5.2	4.0	5.6	4.8	4.9	4.2	4.3	3.7
	Users	5.0	4.1	*4.1**	3.4	5.2	3.7	5.8	4.3	4.4	3.8	4.4	4.1	5.6	4.2	5.9	4.5	4.7	4.6

Note. Comparisons between each option and the overall sample: **Bolded values** are significantly greater than the overall means. *Italicized values* are significantly lower than the overall means.

M = mean, *SD* = standard deviation.

[1]Chi-Square and T-Tests between users and non-users were computed.

* $p < .05$

Significantly more users, overall, had made a financial contribution to installing the safe water option available to them in comparison to non-users ($\chi^2 = 108.70$; $p < .001$). Contributions ranged from 10 BDT[3] to 35’000 BDT, with a median of 700 BDT. All users and non-users had contributed to paying for their household arsenic removal filters. Also, most people had contributed to installing their rainwater harvesters, and their piped water supply systems. Regarding monthly payments, with few exceptions, the only options that people paid for using were community arsenic removal (M = 16.0 BDT, SD = 12.4 BDT) and piped water supply (M = 62.0 BDT, SD = 24.5 BDT).

Table 3 shows that the demographic characteristics of the different groups interviewed were broadly similar, though income was regionally variable: It was higher in areas surveyed for rainwater harvesting and deep tubewell use and lower in areas surveyed for pond sand filters, dug wells, and well-sharing. Income was often, but not always, higher among users than non-users for a given technology.

Factors of acceptance for eight arsenic-safe water options

All psychological factors presented in Table 4 significantly differentiated between non-users and users of arsenic-safe water options ($p < .05$). However, some differences were very small, i.e., regarding severity, factual and action knowledge. Users reported high severity. However, inconsistent with the theoretical assumptions, their vulnerability to developing arsenicosis was low. Water taste and temperature were rated particularly high, but they reported that collecting water was somewhat time-consuming. Users also reported high injunctive norms, medium descriptive norms, high self-efficacy, quite detailed coping planning, and a strong commitment to using safe options.

Non-users showed higher vulnerability than users, with high standard deviations, which indicated different types of non-users: some felt quite vulnerable to developing arsenicosis, whereas others did not. In comparison to users, non-users also showed lower taste and temperature ratings and reported that collecting water from the safe option was quite time-consuming. Furthermore, non-users displayed lower norms, much lower self-efficacy and coping planning, as well as much lower commitment to using safe water options.

[3] Exchange rate was approximately 77 Bangladesh Taka (BDT) per US Dollar.

Table 4. *Perceived risk, attitudes, norms, abilities, and self-regulation by users and non-users of the available arsenic-safe water option*

		Overall[1]		Piped water supply		Deep tubewells		Pond sand filters		Community arsenic-removal		Dug wells		Well-sharing		Rainwater harvesting		Household arsenic-removal	
		M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Risk factors																			
Severity	Non-users	3.20***	0.74	_2.72*_	0.75	3.24	0.58	**3.48***	0.70	3.39	0.70	3.09	1.00	3.25	0.87	_2.97*_	0.70	3.11	0.78
	Users	3.40***	0.67	3.45	0.66	3.44	0.57	3.48	0.53	3.45	0.58	**3.60***	0.64	_3.13*_	0.77	3.27	0.81	3.34	0.77
Vulnerability	Non-users	0.78***	2.04	0.11	1.97	**1.15***	2.18	0.22	2.20	0.73	1.79	1.16	1.88	0.47	2.41	0.46	1.45	0.00	1.66
	Users	-2.28***	1.85	_-2.75*_	1.64	-2.18	2.07	-2.45	1.72	-2.34	1.59	_-1.50*_	2.27	-2.01	1.77	-2.33	1.76	-2.49	1.54
Factual knowledge	Non-users	1.73***	0.61	1.71	0.59	**1.85***	0.54	1.57	0.66	1.68	0.57	_1.25*_	0.64	1.69	0.61	**2.02***	0.45	1.91	0.27
	Users	1.93***	0.47	1.90	0.44	1.95	0.48	1.91	0.44	1.92	0.44	_1.73*_	0.52	1.90	0.47	1.95	0.52	**2.03***	0.44
Attitude factors																			
Taste	Non-users	1.96***	1.81	2.50	1.10	**2.48***	1.46	1.43	2.18	1.33	2.12	_1.05*_	2.24	1.42	1.81	2.22	1.29	2.33	1.66
	Users	3.11***	1.16	**3.55***	0.60	3.21	0.90	2.95	1.23	2.78	1.65	_2.40*_	2.10	_2.85*_	1.02	3.17	0.74	**3.40***	0.63
Temperature	Non-users	1.96***	1.67	**2.83***	0.79	**2.66***	1.15	_1.07*_	1.86	_1.06*_	2.15	_1.20*_	1.87	1.47	1.72	2.16	1.27	0.67	2.29
	Users	2.77***	1.41	**3.20***	1.25	**3.15***	0.86	2.77	1.03	_2.04*_	1.92	_2.22*_	2.09	_2.48*_	1.32	2.82	1.30	2.72	1.44
Time consuming	Non-users	2.38***	1.20	2.06	0.94	**2.83***	1.03	**2.77***	1.17	2.61	1.03	2.16	1.13	2.44	1.00	_1.13*_	0.94	2.56	0.73
	Users	1.52***	1.04	_1.14*_	1.00	1.47	1.10	1.56	1.05	1.48	1.02	**1.88***	1.03	**1.96***	0.85	_1.09*_	0.87	1.59	0.98
Norm factors																			
Descriptive norm	Non-users	1.11***	0.89	1.39	0.70	1.07	0.89	1.23	0.74	1.45	0.97	1.27	1.04	**1.42***	0.77	_0.64*_	0.72	0.89	0.78
	Users	2.28***	1.06	**2.60***	0.86	**2.72***	1.18	2.42	0.91	**2.59***	0.84	_1.97*_	0.78	_1.78*_	0.81	_1.22*_	0.67	_1.82*_	0.98
Injunctive norm	Non-users	2.40***	1.80	2.61	1.09	2.66	1.83	2.60	1.73	**3.00***	1.52	2.30	1.84	_1.56*_	2.03	_1.79*_	1.69	2.67	1.41
	Users	3.13***	1.36	**3.54***	0.70	3.02	1.54	3.20	1.12	3.27	1.12	3.17	1.61	_2.31*_	1.72	2.82	1.71	**3.54***	0.71

Ability factors																			
Action knowledge	Non-users	1.99*	0.99	_1.50*_	0.34	**2.94***	0.78	_1.21*_	0.60	_1.29*_	0.57	_1.46*_	0.53	_1.39*_	0.63	_1.51*_	0.52	1.78	0.67
	Users	1.87*	0.87	_1.50*_	0.64	**2.83***	0.75	_1.15*_	0.46	_1.41*_	0.47	_1.45*_	0.48	_1.44*_	0.00	1.74	0.53	1.77	0.65
Self-efficacy	Non-users	1.37***	1.15	**2.50***	1.04	_1.18*_	1.09	_0.93*_	0.99	1.45	1.03	1.52	1.15	1.33	1.10	1.56	1.24	**2.78***	0.44
	Users	3.27***	0.86	**3.68***	0.65	_3.10*_	0.88	3.42	0.73	3.27	0.65	_2.83*_	1.17	_2.94*_	1.02	3.27	0.89	**3.62***	0.55
Self-regulation factors																			
Coping planning	Non-users	0.97***	0.96	**2.39***	0.78	_0.63*_	0.75	0.95	1.10	1.15	0.91	1.11	0.91	1.11	0.95	1.06	0.93	**2.11***	0.78
	Users	2.06***	1.06	**2.44***	0.90	_1.89*_	1.05	2.08	1.06	1.89	0.98	_1.76*_	1.01	_1.69*_	1.06	2.04	1.04	**2.60***	1.03
Remembering	Non-users	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Users	0.26***	0.56	0.21	0.53	**0.40***	0.70	0.20	0.54	0.20	0.43	0.43	0.77	0.19	0.40	0.00	0.00	_0.18*_	0.43
Commitment	Non-users	1.42***	1.18	**2.06***	0.94	_1.06*_	1.05	1.62	1.12	1.24	1.20	1.63	1.34	_0.97*_	1.11	**2.06***	1.11	1.44	0.88
	Users	3.13***	0.89	**3.60***	0.53	3.02	0.90	3.28	0.74	3.17	0.81	_2.68*_	1.32	_2.79*_	0.95	3.00	0.77	**3.30***	0.72

Note: Comparisons between each option and the overall sample: **Bolded values** are significantly greater than the overall means. *Italicized values* are significantly lower than the overall means. M = mean, SD = standard deviation.

[1] T-Tests between users and non-users were computed.

* $p < .05$; *** $p < .001$.

Answers to an open question yielded deeper insights into the counterintuitive result that users of safe water options felt less vulnerable to developing arsenicosis than non-users. Of all the users of safe options, 639 (81.1%) did not feel vulnerable. The vast majority of them reported that this was due to the fact that they were drinking arsenic-safe water (633; 99.1%). In turn, 274 (57.1%) of all non-users felt vulnerable. Most of them reported that the reason for this was that they drank from arsenic-contaminated (218; 79.6%) or untested tubewells (46; 17%). Finally, 84 (18%) non-users did not feel vulnerable. Of these participants, 30 (36%) reported that this was due to their drinking from arsenic-safe water sometimes or the fact that they had not encountered any problems with the water, even though they had been drinking it for a long time.

Also, the answers to open questions about water taste and temperature were insightful. First of all, the vast majority of participants liked the taste of their drinking water to some extent (1,144 with taste ratings > 0). Only 59 respondents disliked the water from the safe option, and most of them were people with access to dug wells (22; 37%). Of the people who disliked the water's taste, most reported sandy (25%) and iron tastes (25%), as well as bad smells (33%). Participants who liked the taste, however, were not able to clearly describe why. The most frequent answers were that the water had no bad smell (67; 9%) and contained less iron (48; 6%).

Regarding temperature, similar to the taste ratings, only a few respondents disliked this (55; 4%). Most of them were households with access to community arsenic removal filters (29%) or dug wells (26%), as well as household filter owners (13%) and people with access to pond sand filters (13%). Some of the respondents who disliked the water temperature reported that the water was too cold in the winter (26%) or too hot in the summer (26%). Again, as with taste, people who liked the water temperature did not have a clear reason as to why they did.

Most accepted water options: Piped water supply and deep tubewells

Piped water supply and deep tubewells were exceptionally well-supported by the psychological factors (Table 4). Users of piped water supply reported significantly above-average ratings for the taste and rated collecting safe water as below-average in terms of time-consumption than the average study participant. Both users and non-users had significantly higher water temperature ratings. Users also displayed above-average social norms. Furthermore, people with access to piped water supply also displayed above-average self-efficacy, more detailed coping plans, and higher levels of commitment.

Similarly, participants with access to deep tubewells had higher temperature ratings. Non-users, however, rated collecting water from deep tubewells as above-average in terms of being time-consuming. Generally, households with access to deep tubewells displayed higher levels of descriptive norms and above-average action knowledge. In contrast to households with access to piped water supply, however, they had below-average self-efficacy and less detailed coping plans. Finally, non-users displayed below-average levels of commitment.

Least accepted water options: Dug wells and well-sharing

Dug wells and, to a lesser degree, well-sharing were poorly supported by psychological factors. Households with access to dug wells showed significantly lower levels of knowledge compared to other households, as well as the lowest ratings for water taste and temperature. Furthermore, users of dug wells, compared to the average safe water user, perceived collecting water from dug wells as more time-consuming and displayed lower levels of descriptive norms, self-efficacy, coping planning, and commitment.

Households who used neighboring safe tubewells (well-sharers) reported below-average taste and temperature ratings, and found collecting water more time-consuming. Well-sharers also reported lower descriptive norms than the average study participant, whereas for potential well-sharers (households who do not use available neighboring safe wells), the opposite was true. Both well-sharers and potential well-sharers were rated significantly lower in terms of injunctive norms. Furthermore, self-efficacy and coping planning were below average for well-sharers. Finally, commitment was low for both actual and potential well-sharers.

Moderately accepted options: Community and household arsenic removal, rainwater harvesting, and pond sand filters

Community arsenic removal and pond sand filters were both rated average on most factors. The exception for community arsenic removal was water temperature, with which users and non-users were significantly less satisfied than the average study participant. Similarly, non-users of available pond sand filters were significantly less satisfied with water temperature. Furthermore, they found collecting water significantly more time-consuming and were rated significantly lower in self-efficacy than the average non-user in the study.

Users of household filters displayed the highest levels of factual knowledge. Also, water from household filters received the highest taste ratings from users. However, descriptive norms for this option were low, which was also found to be the case for the other household options (i.e., rainwater harvesting and well-sharing). Users and non-users of household arsenic removal filters displayed above-average levels of self-efficacy and coping planning. Finally, users displayed low levels of remembering, but the highest levels of commitment.

Rainwater harvesting was rated as the least time-consuming of all safe options. However, rainwater harvesting was rated as below-average in terms of the descriptive norms. Non-users also reported lower injunctive norms.

Discussion

The aim of the present study was to determine the acceptance and use levels of eight available arsenic-safe water options in Bangladesh. Knowledge of the status quo of people’s acceptance and use of these options will provide a starting point for developing interventions to enhance their sustainable use and can also guide experts in making choices regarding which new options to implement.

A major finding of this study was that one third of households who are at risk of drinking arsenic-contaminated water and who have access to one of the eight arsenic-safe water options in Bangladesh do not use these available safe water options. Some options are used by as little as one-third of those who could make use of them. This implies that the number of people at risk of developing arsenicosis in Bangladesh may be underestimated. Refining behavior change campaigns is an essential step in improving the acceptance and use of the available alternative options. However, technical improvements of safe water technologies may also be in order. The present study provides insights into people’s acceptance. Importantly, it was shown that the RANAS factors reliably differentiate between users and non-users of arsenic-safe water options. In the following, we will discuss, for each safe water option, the psychological factors that were found favorable or unfavorable for the acceptance of an option (Table 4), as well as possible interventions to increase acceptance.

Users of **piped water supply** showed a high degree of acceptance; the vast majority of the related behavioral factors were well above the average of all options. Additionally, users of piped water supplies rate the use of this option as not being very time-consuming and perceive low levels of vulnerability when they drink this water. This finding supports the increased installation of piped water supplies in arsenic-affected areas. However, piped water systems often fail because of technical, institutional, or financial difficulties. Tariff collection, for example, often presents a problem, especially where local administrations have limited capacity. Still, piped water is recognized as a long-term strategic goal by the Government, and it can be expected that as more experience is gained with this technology in Bangladesh, these challenges can be met and overcome.

Deep tubewells also displayed high acceptance scores, but are rated as being time-consuming, which seems to be an issue that people find difficult to cope with. Non-users find this particularly hindering, which is perhaps why their commitment to collecting water from deep tubewells is below average. This might be a reason why only slightly more than half of respondents with access to deep tubewells actually use them. This perception may be changed by adding positive feelings to collecting deep tubewell water, e.g., by promoting collecting water with a friendly companion or having a chat at the deep tube well, etc. (see Mosler et al., 2010). Technical innovations, such as the use of multiple hand pumps attached through lateral pipes to a single borehole, may help overcome distance barriers. Naturally, the installation of greater numbers of deep tubewells will also reduce the distance from users and hence inconvenience.

In this study, households with access to deep tubewells showed greater action knowledge than the average household prone to arsenic contamination. However, this is most likely attributable to the fact that action knowledge was assessed differently in the deep tubewell study than in the 2009 study, when all other arsenic-safe water options were investigated. Further studies should employ consistent knowledge measures and investigate this further.

Household arsenic removal technologies score high in terms of acceptance. One problem here seems to be that users do not perceive that others also use household arsenic-removal. Also, a lack of remembering to use this option was a difficulty revealed in this study. These limitations could be overcome by pointing out other households that use arsenic removal filters and posting graphical reminders at the location where the behavior should be performed (Mosler, 2012).

Our results may be positively biased for household arsenic removal due to the high survey refusal rate: A third of the households listed as having received filters denied ever having received a filter and were therefore not interviewed. This indicates poor acceptance of household filters by at least a part of the population, which is not reflected in our results.

Community arsenic removal technologies reach a medium level of acceptance, except that the norm factors are above average. This means that users perceive many others who also collect water from this source and that others appreciate their use. Users and non-users, however, rate the temperature of the water from this option as problematic. A potential intervention could be to instruct people to cool the treated water via storage in clay pots or via wrapping wet fabric around the water storage containers.

Pond sand filters also reach a medium level of acceptance, but are considered to be time-consuming, and temperature seems to be a problem. Users of pond sand filters, in addition to issues with water temperature and time, face difficulties of self-efficacy; people are not sure they can collect all the water they need from this option. To increase self-efficacy, further information must be collected regarding where the problem lies. For example, if it is a matter of not having enough human resources to collect enough water, other households may be engaged in collecting water together. However, if it is a malfunction of the filter, the device needs to be improved or further water points need to be implemented if not enough water is available for the entire population.

Rainwater harvesting also has only a medium level of acceptance. Although users and non-users both think that rainwater harvesting is not time-consuming, this option scores particularly low in terms of normative factors. This means that people do not perceive many others to be using this option and that not many others appreciate their use. Therein may lay a reason why rainwater harvesting is only used by a few households. A possible intervention to improve normative factors could be to use well-known persons who praise the use of this option.

Dug wells and **well-sharing** score the lowest on acceptance; most of the psychological factors are below average. Both options are rated as being particularly time-consuming. Well-sharing is additionally low in injunctive norm, implying that others do not appreciate the use of this option. For both options, users do not see alternatives that could be used to overcome their barriers (low levels of coping planning), and they are not confident they will get as much water as is needed (low levels of self-efficacy). This all results in users’ low commitment, indicating that if there were another safe water option, these users would change immediately.

Users of both dug wells and well-sharing also reported dissatisfaction with the temperature, taste, and odor of drinking water. The poor taste of water from dug wells is consistent with its relatively poor microbiological quality (Howard, Ahmed, Shamsuddin, Hamud, & Deere, 2006). Household water treatment might improve both the taste and quality of water from dug wells; even simple addition of a few drops of lemon or orange juice could improve the taste. As noted earlier, clay storage containers could cool water during warm seasons. If there are no practical alternatives to the use of dug wells and well-sharing, then it should be planned among the households which other dug wells can be used or to which tube well they can switch if the one they normally use is not accessible. Agreements with the owners of these alternative wells should be arranged. Thus, the households would feel more confident in collecting as much safe water as they need and feel more committed to using safe water.

In contrast with its psychological ratings, **well-sharing** emerged as one of the most used options in this study. This is consistent with previous estimates (Ahmed et al., 2006). It is therefore surprising that well-sharing scored low in terms of psychological factors. This may indicate that people with access to neighboring safe wells do perceive this as the only available safe water option and therefore use it. It seems that well-sharing is perceived as only a temporary solution: if other safe options were installed in the neighborhood, households would most likely prefer these over well-sharing. Furthermore, due to the lack of support from the psychological factors, it seems likely that well-sharers switch back to using their contaminated wells at least occasionally. These assumptions require further investigation.

In conclusion, this study provides insights into people’s differential acceptance of all of the arsenic-safe water options commonly promoted in Bangladesh. For each safe water option, psychological factors have been identified that should be improved in order to increase their acceptance. To maximize the impact of arsenic mitigation efforts, greater emphasis should be given to the installation of psychologically favored options (deep tubewells and piped water supply) rather than poorly supported options (dug wells, pond sand filters, and rainwater harvesting). Well-sharing is also poorly supported and should be seen as only a temporary solution. Regardless of the technology promoted, an understanding of the key underlying psychological factors described in the RANAS model can be used to develop interventions tailored to influencing the relevant drivers of behavior change. This type of ‘smart’ intervention, coupled with sound technologies, has the potential to improve the efficiency of arsenic mitigation efforts.

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Chapter III

Predicting water consumption habits for seven arsenic-safe water options in Bangladesh

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A similar version of this chapter is submitted for publication

(Inauen et al., submitted)

Abstract

Supplying safe water is a great challenge in developing countries. In Bangladesh, 20 million people are at risk of developing arsenicosis resulting from excessive arsenic intake. Despite increased awareness, many of the implemented arsenic-safe water options are not being sufficiently used by the population. This study investigated the role of social-cognitive factors in explaining the habitual use of arsenic-safe water options, as well as the generalizability of that model to seven arsenic-safe water options. 872 randomly selected households in rural Bangladesh were interviewed by structured face-to-face interviews in November 2009. Habitual use of arsenic-safe water options, severity, vulnerability, affective and instrumental attitudes, injunctive and descriptive norms, self-efficacy, and coping planning were measured. Linear regression revealed self-efficacy, components of attitude, vulnerability, as well as injunctive and descriptive norms to mainly explain the habitual use of arsenic-safe water options. This model proved highly generalizable to all seven arsenic-safe water options investigated, even if habitual use of single options were predicted from parameters estimated without these options. This general model for the habitual use of arsenic-safe water options may prove useful to predict other water consumption habits. Behavior change interventions are derived from the model to promote the habitual use of arsenic-safe water options.

Keywords: health behavior; social-cognitive predictors; habitual behavior; developing country; arsenic-safe drinking water; regression; Bangladesh

Introduction

An increasingly serious global topic is the lack of safe drinking water, particularly in developing countries. Worldwide, nearly one billion people do not have access to safe water (United Nations, 2009). One source of contamination is naturally occurring arsenic in groundwater, which affects millions of people in many countries worldwide (Amini, Abbaspour et al., 2008). Continuous arsenic consumption poses a serious health hazard: arsenicosis. In earlier stages, the symptoms of arsenicosis comprise skin diseases, such as keratosis and melanosis. With long-term excessive consumption of arsenic, cancers of various organs, cardiovascular diseases, diabetes, peripheral vascular diseases, and impaired neurodevelopment in children may occur (Wasserman et al., 2004). Prevention of arsenicosis by providing arsenic-safe water is vital because the health effects are irreversible. In Bangladesh, where 20 million people are at risk of drinking water from arsenic-contamianted wells, low-cost safe water alternatives have been installed in many regions. However, some of the installed options are not being used or maintained by the population in the long-term (Hoque et al., 2004; Milton et al., 2007). Why people use or do not use arsenic-safe water options has been a long neglected research subject in arsenic mitigation. The overall aim of this study is to identify factors that can explain people's habitual use of arsenic-safe water options. From health-psychological research we know that health behaviors (e.g., dietary behaviors, smoking cessation, and exercise behaviors) are influenced by social-cognitive factors, such as attitudes, norms, and self-regulatory processes (e.g. Gutiérrez-Doña, Lippke, Renner, Kwon, & Schwarzer, 2009; Scholz, Keller, & Perren, 2009; van Zundert, Ferguson, Shiffman, & Engels, 2010). Understanding the mechanisms of using arsenic-safe water options from a health-psychological perspective is crucial since it will provide a starting point for systematically developing behavior change campaigns to promote these options.

Water consumption and arsenic mitigation in Bangladesh

In rural Bangladesh since the 1970s, most households adopted shallow tubewells as an economical and quickly installed safe-water alternative for microbial infected ponds. However, with the detection of arsenic in shallow tubewells in the mid-1990s, another waterborne health threat emerged. The complex spatial distribution of arsenic in groundwater (neighboring tubewells often differ regarding arsenic contents) required a nationwide well screening. One third (1.4 million) of almost five million tested tubewells were contaminated with arsenic (Johnston & Sarker, 2007).

Consequently, national and international agencies started implementing safe water options to mitigate the problem. Eight water options are currently being implemented in Bangladesh to provide arsenic-safe and pathogen-free water: (a) deep tubewells that tap deeper, arsenic-free aquifers; (b) rainwater harvesting; (c) household arsenic removal filters; (d) community arsenic removal filters; (e) rural piped water supply that provide safe water by distributing deep tubewell or filtered pond and river water; (f) pond sand filters, which remove pathogens from arsenic-free surface water; (g) dug wells, i.e. arsenic-safe very shallow hand dug wells; (h) well-switching, i.e. switching to a neighbor's uncontaminated shallow tubewells.

Few studies have investigated why people do or do not use accessible arsenic-safe water options. These studies have mainly focused on the relationship between people's socioeconomic characteristics and risk awareness (e.g. Parvez et al., 2006; Paul, 2004), although increased awareness often does not translate into increased risk mitigation behavior (Ahmed et al., 2006). One study was found that investigated the factors influencing the use of arsenic-safe deep tubewells based on health-psychological theory (Mosler et al., 2010). Mosler and colleagues showed that the quantity of deep tubewell water consumed depends primarily on the descriptive norm (Mosler et al., 2010); perceptions about which behaviors are typically performed (Cialdini, 2003). Further behavior-influencing factors that were identified included: self-efficacy (the belief in one's capabilities to organize and execute the courses of action required to manage prospective situations, Bandura, 1997), the injunctive norm (perceptions about which behaviors are typically approved or disapproved, Schultz, Nolan, Cialdini, Goldstein, & Griskevicius, 2007), and the preference for the taste of the water from the arsenic-contaminated tubewell. However, several variables in the model (e.g. self-efficacy) were imprecisely defined and conceptualized, which led to interdependencies between predictors. More importantly, some potentially influential social-cognitive factors, such as coping planning, were not included in the model. Building a more comprehensive model, which can be generalized to more safe water options, would be beneficial.

Social-cognitive predictors of safe water consumption

As a basis for deriving influential factors impacting the use of safe drinking water options, we drew on the Health Action Process Approach (HAPA; Schwarzer, 2008). This theory has been successfully applied to explain many health behaviors (e.g. Schwarzer, 2008). The HAPA specifies risk perception, outcome expectancies, self-efficacy, and planning as behavior-influencing factors. To gain more intervention relevant information (for interventions corresponding to behavior-influencing factors, see Mosler [2012]), we further split risk perception and outcome expectancies into several factors.

For risk perception, we considered perceived vulnerability, a person's subjective perception of his or her risk of contracting a particular condition or illness, and perceived severity, a person's perception concerning the seriousness of the consequences of contracting a particular condition or illness (Brewer, Chapman, Gibbons, McCaul, & Weinstein, 2007; Floyd, Prentice-Dunn, & Rogers, 2000).

As outcome expectancies, we considered social, physical and emotional components (Schwarzer, 2008). For the social influences we distinguish between the aforementioned injunctive and descriptive norms. Corresponding to the physical and emotional components of the HAPA (Schwarzer, 2008), we considered affective (e.g. enjoyable / unenjoyable) and instrumental (e.g. beneficial / harmful) evaluations of the behavior (Trafimow & Sheeran, 1998).

As another component of the HAPA (Schwarzer, 2008) we take into account self-efficacy, and, finally, planning is considered. In the planning component of the HAPA (Schwarzer, 2008) we have action as well as coping planning. Coping planning is the presumption of possible barriers and the invention of ways to overcoming them (Schwarzer, 2008). Action planning, in turn, is the forming of plans to initiate a new behavior. We therefore excluded this factor from our model, because we aim at explaining the habitual use of arsenic-safe water options, and not only their adoption.

In addition to the psychological factors related to the target behavior, we argue that it is important to consider these factors for the competing behavior. Every behavior has an alternative, and new behaviors will be weighed against old behaviors serving similar purposes. For the case of drinking water in Bangladesh, we have to consider factors that support the use of arsenic-contaminated water options in addition to the ones that favor the use of arsenic-safe water options.

Towards understanding, predicting and creating habitual behaviors

To avoid most health threats, including arsenicosis, it is not only necessary to adopt a healthy behavior, but to maintain this practice over time. The goal of every behavior change campaign is thus to induce long-lasting behavior change. One indicator of sustained behavior is habits. They facilitate intended behaviors, because they require reduced cognitive effort (Tobias, 2009). We therefore propose to consider creating habits as an important additional goal of behavior change campaigns, as has also been suggested by Verplanken and Wood (2006). Consequently, habits should be considered as a dependent variable in statistical investigations in order to identify their behavioral determinants that, in turn, can be targeted in behavior change campaigns (cf. Orbell & Verplanken, 2010; Verplanken & Melkevik, 2008). However, explaining and predicting habits alone seems not sufficient. Particularly in the case of promoting a new behavior, some individuals may already perform it, but have not yet developed habits. Other individuals, in turn, may not be performing the behavior at all yet. To consider all indiviuals simultaneously, the actual behavior should be part of the predicted construct in addition to the stability of this behavior (i.e. the habit). In this study we use the concept of *habitual behavior* that comprises both habit and the actual behavior. Such a scale is a continuum which allows the simultaneous consideration of both current users and non-users of a target behavior, including their degrees of habit to perform it. A further advantage of combining behavior with habit strength in this scale is to have a measure of continuity of a behavior that can also be assessed in cross-sectional surveys. On one side of this continuum, people are represented who are not yet performing the behavior, and who have never done so in the past (i.e. zero habit). On the other side of the continuum, people are currently performing the behavior with great automaticity and regularity (i.e. great habit strength). In between these extremes are people who are not yet performing the behavior with regularity. These are, for example, people with some habit for the behavior, but who do not currently perform it (e.g. because they just moved to a new area). Or, people who just started performing the behavior, but have not yet achieved any habit, wherefore their practices are vulnerable to change.

The present study

The aim of this study was to develop a simple linear model to explain and predict water-consumption habits based on data on the consumption of arsenic-safe water in Bangladesh. The foundation for this study involved existing studies on water-consumption behavior and theories on determinants of health behaviors, as presented above. The model to be developed aims at predicting an entire class of specific behaviors, i.e. the habitual use of each of all arsenic-safe water options. Therefore, generalizability becomes an issue: We must investigate how well the model predicts the habitual use of a specific option based on the model of all other water options it presumes to explain.

To conclude, this study investigates two research questions: 1) which factors are related to the habitual use of arsenic-safe water options and what are their parameter estimates? 2) How well does this general model predict the use of specific water options based on the model for all water options for which it was built (i.e., all arsenic-safewater options in Bangladesh)?

To investigate our first research question, the following hypotheses were derived from the HAPA (Schwarzer, 2008): Increased habitual use of arsenic-safe water options will go in line with increased perceived severity (H1), increased perceived vulnerability (H2), more positive affective (H3) and instrumental attitudes (H4) regarding the arsenic-safe water option, more favorable injunctive (H5) and descriptive norms (H6) towards the arsenic-safe option, increased self-efficacy (H7), and more detailed coping planning (H8). In turn, we expect less habitual use of arsenic-safe water options to be associated with increased affective attitudes (H9), and increased descriptive norms (H10) regarding arsenic contaminated tubewells.

For the second research question, separate forecasts for the habitual use of each specific arsenic-safe water option are derived from the model with parameter values that were estimated with the entire sample. Findings of this study will add to understanding and predicting habitual safe-water consumption. Furthermore, theory-based behavior change interventions to enhance the habitual use of arsenic-safe drinking water options are derived from the results of this study.

Method

Participants and procedures

Criteria for study participation were (a) exposure to the risk of drinking arsenic-contaminated water (i.e. households who reported to own or have access to an arsenic-contaminated tubewell, in case they do not own a well), and (b) having access to one of seven arsenic-safe water options: household arsenic removal filters, household rainwater harvesting, community arsenic removal filters, rural piped water supply, pond sand filters, dug wells, and well-switching. The aim was to survey 125 households for each water option. We excluded people with access to deep tubewells from the study, because we had previously studied the use of deep tubewells (Mosler et al., 2010).

The study areas comprised 40 rural villages of six arsenic-affected districts of Bangladesh: Satkhira, Khulna, Bagerhat, Comilla, Munshiganj, and Brahmanbaria districts. We purposefully selected these villages due to the presence of high arsenic-contamination, and availability of any of the seven arsenic-safe water options of interest to this study.

The survey was carried out by 12 professional Bangladeshi interviewers in November 2009. Conducting structured psychological surveys in rural areas of developing countries is always a challenge. Most people, particularly in rural areas, are not used to answering questions, and the psychological response format is novel. We therefore devoted much time and effort to interviewer training to rehearse interviewing techniques to facilitate respondents' understanding and answering. Two local supervisors assisted the interviewers and performed data quality checks with the first author and a master's student. Within a given study area, interviewers selected households by random-route sampling (e.g. Hoffmeyer-Zlotnik, 2003). Interviewers first screened whether the household met inclusion criteria. Then, the interviewer asked for the person of the household who was responsible for water provision. After obtaining informed consent, the interview was conducted. Interview durations ranged from one to 1.5 hours.

In total, 872 households were interviewed: 126 who owned a household arsenic-removal filter, 123 who owned or had access to a rainwater harvester, 124 with access to dug wells, and 125 each with access to piped water supply, pond sand filters, community arsenic removal filters, or a neighbor's uncontaminated tubewell (i.e. well-switching). None of the approached households refused the interview, although interviewers emphasized that participation was voluntary. However, 30% of potential participants who had once received household filters stated that they had never received one, which may be interpreted as a refusal. On average, households had 5.4 members and the average monthly household income was 8961 Bangladeshi Taka (BDT; app. 106 US Dollars). The majority of the participants were female (71%). They were, on average, 37.6 years old (*SD* = 12.6 years), and the majority were housewives (66.7%). Other occupations included: agricultural work (10.3%), independent work (e.g. local business ventures; 10.8%), and others (e.g. studies, retirement; 12.2%). One third of participants had received no formal education (33.7%), one third had gone to school for 1 to 6 years (31.6%), and another third (34.5%) had been to school for 7 to 17 years.

Measures

A structured questionnaire was specifically developed for this study. The majority of items were derived from the literature (Mosler et al., 2010, if not indicated otherwise) and adapted for Bangladesh and the water consumption context where necessary.

The questionnaire included structured items addressing water consumption behavior, psychological variables, and sociodemographic information, as well as open questions dealing with the advantages and disadvantages of different water options. The questionnaire was translated into Bengali and re-translated into English to verify the quality of the translation. During questionnaire preparation and pretest, we worked closely with local collaborators to ensure understanding of our questions and answer formats by the rural population.

To build scales, items were averaged. Unipolar items offered five response options (from 0 to 4), bipolar items offered 9-point scales: 4 points into one direction (e.g. from rather dislike it to dislike it very much), 4 points into the opposite direction (e.g. from rather like it to like it very much), and one neutral point (e.g. neither particularly like it nor dislike it). Note that there was a questionnaire version for each of the seven arsenic-safe water options, in which the term “arsenic-safe water option” was replaced correspondingly. In the following, a brief overview of the aspects included in each construct of this study is provided. A detailed overview of all constructs and their operationalization can be found in the supporting information (see Appendix II).

Dependent variable: Habitual behavior. As proposed in the introduction, we employed a new composite measure for habitual behavior. It consisted of a measure for current behavior, as well as three components of self-reported habit: perceived habit, automaticity, and regularity.

The proportion of arsenic-safe water of the total drinking water consumption was the behavioral measure. This was assessed by asking respondents how many vessels of drinking water their household consumed per day, in total and per water option. From this, the proportion of arsenic-safe water of the total drinking water consumed per day was calculated. Because all of our participants only used one source per day for drinking (i.e. 0% or 100% arsenic-safe water), we coded this into 0 (0%) and 4 (100%). To include the habit aspect into our composite measure of habitual behavior, we assessed self-reported habit with three items. The first item directly measured perceived habit by assessing respondents’ agreement to the statement, “collecting water from the arsenic-safe water option is something I do as a matter of habit” on a 5-point scale (0 = strongly disagree to 4 = strongly agree). Furthermore, in accordance with the Self-Report Habit Index (SRHI; Verplanken & Orbell, 2003), we measured perceived automaticity of the behavior by asking, “do you collect water from the arsenic-safe water option automatically?” (0 = not at all automatically to 4 = very automatically). To assess the regularity component of habit, respondents were first asked to answer an open question regarding when they normally went to collect water from the arsenic-safe option (an event or time). Then, regularity was assessed by respondents’ estimation of how often they collected water at the indicated time or event (0 = almost never to 4 = almost always).

To build the habitual behavior scale, the current behavior and the three habit items were averaged. The scale displayed high internal consistency (Cronbach's α = .91), and ranged from zero (i.e. no habitual behavior) to four (i.e. very habitual behavior).

Psychological predictors of habitual behavior. *Severity* was measured utilizing three items, which assessed, how severely respondents judged the general, social, and economic consequences of contracting arsenicosis. For example, respondents were asked: "Imagine that you contracted arsenicosis, how severe would be the impact on your life in general?" (0 = not at all severe to 4 very severe). The severity scale displayed very high internal consistency (Cronbach's α = .95).

Vulnerability was operationalized with two items that assessed how high or low respondents rated their likelihood of either developing arsenicosis themselves or that their families would develop the disease, respectively (9-point scale from -4 = very low to 4 = very high, Cronbach's α = .96).

We constructed three outcome expectancy factors: the affective and instrumental attitudes regarding the arsenic-safe water option, and the affective attitude regarding either the contaminated or untested shallow tubewell. The *affective attitude towards the arsenic-safe option* included five items regarding how much individuals preferred the arsenic-safe option overall, as well as the water's taste, smell, temperature, and color. We asked respondents, for example, "how much do you like or dislike the taste of water from the arsenic-safe water option?" Nine response options were offered, ranging from - 4 (dislike it very much) to 4 (like it very much). Cronbach's Alpha of this scale was very high (α = .93).

The *instrumental attitude towards the arsenic-safe option* included four items. Two questions assessed whether collecting water from the arsenic-safe option was perceived as time-consuming or effortful respectively (0 = not at all time-consuming / effortful to 4 = very time-consuming / effortful). Furthermore, we included two numeric variables that were created from open questions: one reflected the number of responses given to the open question, whether respondents perceived any advantages regarding using the contaminated or untested tubewell. The other item reflected the number of disadvantages respondents reported regarding using the arsenic-safe water option. The internal consistency of this scale was satisfactory (Cronbach's α = .67). The final scale was inverted: higher values in instrumental attitudes reflected more positive attitudes towards habitual behavior.

Finally, the *affective attitude towards the contaminated or untested tubewell* included the same items as the affective attitude towards the arsenic-safe option, but referred to the alternative behavior (Cronbach's α = .89).

The *injunctive norm regarding the arsenic-safe option* comprised three items, all indicating respondents' perceptions of what others thought whether using arsenic-safe water options was appropriate. Participants were asked, for example: "How proud or ashamed are you to offer water from the arsenic-safe water option to your guests?" (9-point scale ranging from -4 = very ashamed to 4 = very proud). Cronbach's Alpha for this scale was .80.

Two descriptive norms were assessed: the *descriptive norm regarding the arsenic-safe option* (Cronbach's α = .59), and the *descriptive norm regarding the arsenic-contaminated or untested shallow tubewell* (Cronbach's α = .67). Two items for each the arsenic-safe option and either the arsenic-contaminated or untested tubewell were employed. The first item asked how many of respondents' relatives (excluding people living in the household) drink water from the arsenic-safe option and the arsenic-contaminated or untested tubewell respectively (0 = almost nobody to 4 = almost all of them). The second item asked the same question but with regard to how many people outside their families drink the water.

Three items were used to assess *self-efficacy*. These were derived from the HAPA's action self-efficacy measure (Schwarzer, 2008). Interviewers asked respondents, for example: "Are you sure that you can collect as much arsenic-free water from the arsenic-safe water option as you need within the next year?" (0 = not at all sure to 4 = very sure). The internal consistency of this scale was high (Cronbach's α = .91).

Finally, *coping planning* was assessed with two items adapted from the HAPA (Schwarzer, 2008). Participants were asked, for example, "Have you made a detailed plan regarding what to do when the arsenic-safe water option gets broken?" (0 = no detailed plan at all to 4 = very detailed plan). Cronbach's Alpha for coping planning indicated high internal consistency for this scale (α = .92).

Data analysis

All analyses were calculated with SPSS 18.0. Simultaneous multiple linear regressions were computed to explain the habitual use of arsenic-safe water options by the psychological predictors. Assumptions of linearity, homoscedasticity, and normally distributed error terms were met for the entire sample and all sub-samples. Multicollinearity was a minor issue for the majority of variables: most variance inflation factors (VIF) were smaller than 1.8. However, some multicollinearity was found for the injunctive norm and self-efficacy (VIF_{max} = 2.8). The intercorrelations confirm these observations (see Table 5). Furthermore, they reveal particular interrelatedness of the affective attitude regarding the arsenic-safe water option, the injunctive norm, and self-efficacy, as well as self-efficacy and coping planning.

The model developed in this study claims not only to explain the habitual use of one specific water option, but to be generalizable to an entire class of water options as well. Therefore, the model cannot be evaluated merely by fitting it to the data but the generalizability of its data-fitting abilities (Pitt & Myung, 2002) must be tested. The method of choice for such a task is cross validation, whereby model parameters (here the parameters b_0 to b_p of the regression equation $Y = b_0 + b_1*X_1 + ... + b_p*X_p$) are estimated with one sub-set of the data and then, with another sub-set, the habitual behavior is predicted with the previously estimated parameters. If the two sub-sets of data refer to the habitual use of different water options, this test not only provides information about the generalizability of the model to other samples but also to the habitual use of other water options.

In total, the model was fitted to nine data sets (i.e., sub-samples of the total sample). In Estimate 1, the whole sample was used to estimate the regression parameters. With these parameter estimates, forecasts of the habitual use of the seven water options were computed for each participant: Firstly, the parameter estimates from the regression were entered into the regression equation. Thereby, the habitual behavior of each participant was predicted by the model (Estimate 1). To get a measure of how well the model predicted habitual use of each arsenic-safe water option, we then calculated a Pearson Correlation between the predicted habitual behavior value and the observed habitual behavior of each participant. This correlation was computed for each of the seven arsenic-safe water options, as well as for the total sample. The squared values of these correlations (i.e., R^2) gives a first indicator of the generalizability of the model for each of the seven options: the smaller the variation of the model fit for a specific water option compared to the fit to the whole sample (i.e. all water options), the higher the generalizability to this particular option. Thereby, it is possible to identify which water options can be forecasted better or worse. In further generalizability tests, the above explained procedure was repeated for other sub-sets of the data: Seven estimates were calculated using the data of six water options and omitting the data of one water option (Estimates 2 to 8). This highlights how the model may perform if applied to a similar water option not included in the data set for estimating the parameters. Again, this investigation can be used to identify the habitual use of water options that are difficult to forecast with this model. Finally, two more strict cross-validations were calculated. For Estimate 9, the two best-explained water options were excluded from the parameter estimation. In turn, for Estimate 10, the two worst-explained water options were excluded to estimate the regression parameters. Then, again, these parameters were entered into the regression equation to forecast the habitual use of each of the water options: once with parameters from Estimate 9, once for those from Estimate 10. Splitting the sample in this form maximized the differences between the subsamples, and thus, the difficulty of the forecast.

Results

Descriptive statistics

Overall, 65.8% (574) households used the available arsenic-safe water options for drinking. However, user rates differed considerably between the water options. At the time of the interview, of the households to whom the respective water option was available, 36.6% (45) used rainwater harvesters, 92.9% (117) used household filters, 73.6% (92) used community filters, 51.6% (64) used pond sand filters, 85.6% (107) used piped water supply, 48.4% (60) used dug wells, and 72.2% (89) used neighboring arsenic-safe wells. Further descriptive statistics and intercorrelations of habitual behavior and all psychological predictors in the study can be found in Table 5).

Overall model to explain the habitual use of arsenic-safe water options

All psychological variables were significantly correlated with habitual behavior (see Table 5). After eliminating five outliers with residuals greater than three, the final regression model was computed. Six of the ten psychological predictors significantly contributed to explaining the habitual use of arsenic-safe water options (see Table 6). In line with our hypotheses, the instrumental attitude safe water (H4), the injunctive norm (H5), the descriptive norm safe water (H6), self-efficacy (H7), as well as the affective attitude towards the contaminated tubewell (H9) were significantly predicting habitual use of arsenic-safe water options. The strongest predictors of habitual behavior were self-efficacy, the descriptive norm regarding the arsenic-safe water option, and the instrumental attitude regarding the safe option. Furthermore, vulnerability was significantly associated with habitual use of arsenic-safe water options. However, contrary to our hypothesis (H2), vulnerability was negatively associated with habitual behavior. Finally, severity (H1), the affective attitude towards the safe option (H3), the descriptive norm regarding contaminated or untested tubewell (H8), and coping planning (H10) were not significantly associated with habitual use of arsenic-safe water options. The overall model explained habitual use of arsenic-safe water options well (R^2 = 0.688).

Table 5. *Descriptive statistics and correlations for dependent and independent variables (N = 872)*

	M	*SD*	Skew	Pearson correlations[a]									
Variable	(Q1)	(Q2)	(Q3)	1	2	3	4	5	6	7	8	9	10
1. Habitual behavior	(0.75)	(2.88)	(3.38)										
2. Severity	3.33	0.71	-0.87	**0.20**									
3. Vulnerability	-1.34	2.19	0.42	**-0.59**	**-0.14**								
4. Affective attitude arsenic-safe option	2.51	1.47	-1.83	**0.50**	**0.21**	**-0.30**							
5. Instrumental attitude arsenic-safe option	2.38	0.76	-0.22	**0.29**	**-0.22**	**-0.10[b]**	**0.24**						
6. Affective attitude contaminated tubewell	-1.42	1.88	0.57	**-0.32**	**-0.27**	**0.29**	**-0.36**	-0.04[f]					
7. Injunctive norm arsenic-safe option	2.57	1.08	-0.76	**0.52**	**0.46**	**-0.38**	**0.62**	**0.08[c]**	**-0.49**				
8. Descriptive norm arsenic-safe option	1.50	0.93	0.38	**0.49**	**0.12**	**-0.27**	**0.27**	**0.12[d]**	**-0.13**	**0.28**			
9. Descriptive norm contaminated tubewell	1.22	0.75	1.05	**-0.31**	**-0.07[e]**	**0.32**	**-0.17**	**-0.11[d]**	**0.21**	**-0.23**	**-0.29**		
10. Self-efficacy arsenic-safe option	2.73	1.23	-0.71	**0.67**	**0.21**	**-0.52**	**0.52**	**0.23**	**-0.38**	**0.55**	**0.43**	**-0.32**	
11. Coping planning	1.76	1.11	0.20	**0.37**	**-0.16**	**-0.29**	**0.31**	**0.22**	**-0.17**	**0.31**	**0.31**	**-0.21**	**0.52**

Note. All variables ranged from 0 to 4, except for vulnerability, the affective attitudes and the injunctive norm, which ranged from -4 to 4.

In parentheses: Quartiles (Q) are displayed due to the non-normal distribution of habitual behavior; Q1 = 25%, Q2 = 50%, Q3 = 75%.

[a] Except for correlations with habitual behavior. These are Spearmen correlations due to the non-normality of habitual behavior.

Boldface: significant with $p < .001$, except for the following: [b] $p = .003$; [c] $p = .015$; [d] $p = .001$; [e] $p = .046$. Not significant: [f] $p = .248$.

Table 6. *Simultaneous multiple linear regression of the habitual use of an arsenic-safe drinking water option (n = 867)*

Predictors	*B*	*SE B*	*p*	95% CI for B *LL*	*UL*
(Constant)	-0.54	0.20	0.006	-0.92	-0.15
Severity	0.00	0.05	0.971	-0.09	0.09
Vulnerability	-0.20	0.02	0.000	-0.23	-0.17
Affective attitude arsenic-safe option	0.00	0.03	0.908	-0.05	0.05
Instrumental attitude arsenic-safe option	0.24	0.04	0.000	0.16	0.31
Affective attitude contaminated tubewell	-0.04	0.02	0.024	-0.07	-0.01
Injunctive norm arsenic-safe option	0.08	0.04	0.049	0.00	0.15
Descriptive norm arsenic-safe option	0.34	0.03	0.000	0.27	0.40
Descriptive norm contaminated tubewell	-0.02	0.04	0.588	-0.10	0.06
Self-efficacy arsenic-safe option	0.42	0.03	0.000	0.36	0.49
Coping planning	0.03	0.03	0.390	-0.03	0.09

Note. CI = confidence interval; *LL* = lower limit; *UL* = upper limit. *SE B* = standard error of unstandardized regression parameter B.

Habitual behavior and all predictors ranged from 0 to 4, except for vulnerability, the affective attitudes and the injunctive norm, which ranged from -4 to 4.

Standardized parameters (β) are not displayed due to the non-normal distribution of the dependent variable.

R^2= 0.688, $F(10, 866) = 188.41$, $p < .001$.

Generalizability of the model for different arsenic-safe water options

The results regarding the generalizability of the model are displayed in Table 7. Furthermore, the regression parameters for each estimate can be found in the supporting information (see Appendix II). The regression parameters that were estimated with the total sample (Table 6) predicted the habitual use well for each of the seven arsenic-safe water options (see Table 7, Estimate 1). In particular, the habitual use of pond sand filters, and community arsenic removal were effectively predicted, with explained variances of 0.801 and 0.748 respectively. Habitual use of well-switching, dug wells, and piped water supply achieved high predictive value as well (R^2 ranged from 0.640 to 0.646). The lowest explained variances was found for household arsenic removal (R^2 = 0.510) and rainwater harvesting (R^2 = 0.539). This indicates that the habitual use of these options is more difficult to forecast with this model than the other behaviors.

Table 7. *Explained variances (R^2, all $p < .001$) of predictions of habitual use for different arsenic-safe water options by parameters estimated with sub-samples of the total sample*

Estimate (sub-samples)	1 Rainwater harvesting	2 Household arsenic removal	3 Commun. arsenic removal	4 Pond sand filter	5 Piped water supply	6 Dug well	7 Well-switching	All
Estimate 1 (total sample)	0.539	0.510	0.748	0.801	0.640	0.646	0.643	0.688
Estimate 2 (without 1)	**0.524**	0.539	0.763	0.806	0.647	0.657	0.631	0.681
Estimate 3 (without 2)	0.539	**0.448**	0.743	0.800	0.627	0.635	0.645	0.687
Estimate 4 (without 3)	0.545	0.520	**0.735**	0.793	0.634	0.640	0.646	0.689
Estimate 5 (without 4)	0.546	0.522	0.732	**0.789**	0.637	0.646	0.635	0.689
Estimate 6 (without 5)	0.540	0.494	0.743	0.798	**0.621**	0.646	0.638	0.689
Estimate 7 (without 6)	0.535	0.485	0.743	0.800	0.640	**0.625**	0.650	0.688
Estimate 8 (without 7)	0.536	0.524	0.755	0.804	0.657	0.650	**0.637**	0.689
Estimate 9 (without 3 and 4)	0.557	0.530	**0.704**	**0.771**	0.620	0.634	0.635	0.683
Estimate 10 (without 1 and 2)	**0.525**	**0.499**	0.767	0.808	0.638	0.653	0.634	0.679
n (per predicted option)	125	126	122	122	125	122	125	867

Note. Explained variance of predictions for options from estimates that were calibrated without these options are in boldface.

A first test of the generalizability of the overall model was to predict habitual use of each option from regression parameters estimated from data without this particular option (Estimates 2 to 7). The results of these tests demonstrated high robustness for the majority of predictions. Explained variances remained nearly the same for most of the options. The largest change in explained variance was found for the habitual use of household filters, which dropped from 0.510 to 0.448.

In a second and stricter cross validation, we excluded the best-explained options from the parameter estimation (Estimate 9). The results of this test revealed a surprising generalizability of the model. The drops in explained variance compared to the reference estimates were minimal, and for all behaviors, except for household arsenic removal, more than half of the variance was explained.

Discussion

This study investigated the importance of psychological factors derived from health behavior theories to predict the habitual use of arsenic-safe drinking water options. Furthermore, we investigated how well this general model can predict the use of specific arsenic-safe water options. Results from a large household survey in Bangladesh showed that the habitual use of arsenic-safe water options is strongly associated with self-efficacy, the descriptive norm, and the instrumental attitude towards the safe water option. Additional related factors were identified, including: the injunctive norm, vulnerability, and attitude towards the health-risking water option (i.e. the arsenic-contaminated or untested shallow tubewell). This corroborates recent findings that social-cognitive factors are highly predictive of safe-water consumption (Huber, Bhend & Mosler, 2012; Huber & Mosler, 2012). The model proved highly generalizable to explain the habitual use of all seven arsenic-safe water options investigated, even when the habitual use of these options was predicted from parameters estimated without data of these options.

The results of this study confirm the findings of Mosler et al. (2010) that norms and self-efficacy are major drivers of safe water collection. These results can be regarded as quite generalizable, because they were replicated in the present study for various safe water options, different operationalization of constructs, and greater sample size.

Regarding psychological predictors of the habitual use of arsenic-safe water options, contrary to our hypotheses, no significant associations between habitual behavior with severity, affective attitude towards the safe water option, descriptive norm regarding the contaminated or untested shallow tubewell, and coping planning were found. However, discarding these factors as unimportant may be premature, as our data also revealed some interrelatedness between constructs. For example, there was an association between the injunctive norm and affective attitude towards the arsenic-safe water option. From a modeling perspective, this indicates that it may be beneficial to combine attitudinal and normative expectancies into one factor, outcome expectancies, as proposed by the social cognitive theory (Bandura, 2004) and the HAPA (Schwarzer, 2008). From the point of view of intervention design, this result suggests that these factors should not be entirely neglected when designing campaigns aimed at increasing arsenic-safe water consumption.

As a separate influence, our study demonstrated that it can be valuable to consider the behavior alternative independent of the target behavior: the affective attitude towards the contaminated or untested tubewell was negatively associated with habitual behavior.

One surprising result of our study is the negative association between vulnerability and habitual behavior. At first, this result may seem to be in contrast with theory, which assumes more health-protective action for people with higher vulnerability (Prentice-Dunn & Rogers, 1986). However, one possible interpretation may be that people who engage in health-protective actions consequently feel less vulnerable to health threats. Longitudinal research may prove more conclusive of the causality of this relation.

One strength of this study is the simultaneous investigation of several behaviors (i.e. several safe water options), which allows a general model to be utilized to test an entire class of specific behaviors. In a number of analyses, the general model not only proved successful for forecasting each of the specific water options investigated, but also proved apt to forecast the habitual use of water options with model parameters that were estimated without these options. However, the habitual use of some water options turned out to be more difficult to forecast than others. Habitual use of rainwater harvesting and household filters was less well-explained than for the other options. One reason may be that both of these options are household-based, whereas the other options are designed for communities or a group of households. This explanation is supported by the fact that these options were better forecasted when community arsenic removal and pond sand filters, the best-explained options that are both clear-cut community options, were excluded from the estimation. Since any model testing can only be done with available data, it remains unknown whether the good generalizability of the model as observed in this study holds for water options not considered in this study. Therefore, in future studies, the generalizability of the model to water consumption habits that were not included in this study (e.g., chlorination, boiling) and other populations (e.g., in other countries) should be investigated.

A shortcoming of the presented study is its cross-sectional design. The causality of the relationships cannot be investigated with such data. In order to investigate whether the relationships we discovered are of causal nature, and in which direction causality runs, longitudinal studies with controlled manipulations of the parameters are necessary. Such data will soon become available, since behavior change campaigns for enhancing the habitual use of arsenic-safe water options are in preparation. From a behavior change perspective, another shortcoming of the study is the inclusion of the very general concept of self-efficacy in the model. In contrast to the other constructs employed, self-efficacy, for its broadness, is difficult to be targeted directly by commonly used interventions. Therefore, in future studies, different types of self-efficacy should be distinguished (e.g., maintenance and recovery self-efficacy; Schwarzer, 2008). Furthermore, determinants of self-efficacy should be explored, such as those suggested by social learning theory (e.g., verbal persuasion, Bandura, 1982). Finally, the measures for habitual behavior we used were self-report and therefore potentially prone to reporting bias. However, we argue that a potential bias may have been reduced by the combination of current behavior with perceived habit. Questions regarding water consumption are arguably more vulnerable to social desirability, because the desired answer can be easily guessed. In turn, questions on perceived habit are more abstract. Therefore, their purpose and thus the socially ‘correct’ answer may not be as apparent as it is for water consumption. If future investigations will find support for this assumption, this would be another advantage of applying this behavioral measure, also in related fields. Future investigations of habitual behavior may also explore whether a stronger weighing of the current behavior in the habitual behavior scale may be beneficial.

Implications for Practice and Conclusions

A general model for predicting water-consumption habits is highly valuable for planning, guiding, and evaluating campaigns aimed at increasing these habits. The model factors can be systematically targeted in behavior change campaigns. Our results suggest a combination of self-efficacy and normative interventions. One intervention strategy that targets both of these factors is modeling (i.e. observational learning; Bandura, 1982). Motivated members of the target communities who are already using arsenic-safe water options can be recruited as promoters. During their visits, the promoters would assist households to locate a nearby arsenic-safe water option for them. Then, the promoter and the person responsible for water collection in the household would go to collect water from this option together. The target person can thereby gain experience that the water source is indeed accessible, which should increase self-efficacy, and also lower perceived expenditure of time (i.e. increase instrumental attitudes). At the same time, the descriptive norm becomes more salient, by meeting a community member who is using arsenic-safe water. Moreover, the injunctive norm can be increased by the promoters' talking positively about using arsenic-safe water options. For this purpose it is ideal to recruit opinion leaders as promoters (i.e. people whose opinion is valued by most community members). Finally, to increase perceived vulnerability, it is advisable that the promoter explains about arsenic, arsenicosis, and arsenic-safe water options, for example by demonstrating pictograms.

In conclusion, due to its generalizability, the model can be applied to predict, and serve as a basis to promote the habitual use of any arsenic-safe water option. Furthermore, it may even be useful for understanding and promoting behaviors that were not considered in the estimation of the parameters. The latter point is of particular importance since an increasing number of technical solutions for providing safe drinking water are being developed. Thus, the model presented can be used to develop theory-based interventions targeting the determinants of habitual behavior.

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Chapter IV

Developing and testing theory-based and evidence-based interventions to promote switching to arsenic-safe wells in Bangladesh

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A similar version of this chapter is submitted for publication

(Inauen & Mosler, submitted)

Abstract

Millions of people in Bangladesh drink arsenic-contaminated water despite an increased awareness of consequences to health. Theory-based and evidence-based interventions are likely to have greater impact on people switching to existing arsenic-safe wells than commonly applied informational interventions. To test this assumption, we first developed interventions based on an assessment of the predictors of health behavior change. In the second part of this study, a cluster-randomized controlled trial with four arms revealed that, in accordance with our hypotheses, information alone showed smaller increases in switching to arsenic-safe wells than information with reminders or information with reminders and implementation intentions.

Keywords: intervention; health behavior; theory; social cognitions; randomized controlled trial

Introduction

Geogenic contamination of drinking water poses a severe threat to global health. In Bangladesh, 20 million people are at risk of drinking arsenic-contaminated water from shallow tubewells (Johnston & Sarker, 2007). The continuous consumption of arsenic can lead to *arsenicosis*, which comprises skin alterations, cardiovascular diseases, and a variety of cancers (Smith & Steinmaus, 2009) and has been associated with increased mortality (Argos et al., 2010). As no cure for the disease has been found, preventing arsenicosis by drinking arsenic-safe water is the main mitigation approach. National and international agencies have put great emphasis on mitigating the arsenic crisis by water testing shallow tubewells and by raising awareness. However, many Bangladeshi still use contaminated wells despite increased awareness of the threat of developing arsenicosis (Johnston & Sarker, 2007), and despite the fact that many live within walking distance of a safe water alternative (van Geen et al., 2002).

From a health psychology perspective this finding is not astonishing. Evidence from studies on safe water consumption (Huber, Bhend & Mosler, 2011; Tobias & Berg, 2011) and other health behaviors have shown that risk perception is often a weak predictor of health behavior change (e.g. Radtke, Scholz, Keller & Hornung, 2011; Schwarzer & Luszczynska, 2008). Therefore, evidenced health behavior change models take into account additional factors, e.g. attitudes, social norms or self-regulation. Basing interventions on evidenced psychological theory should then produce a more successful behavior change than conveying information alone (Michie & Johnston, 2012; Michie et al., 2008).

To determine factors that influence the use of safe drinking water options, we drew on the Health Action Process Approach (HAPA) (Schwarzer, 2008). This theory has successfully explained many health behaviors (e.g. Schwarzer, 2008). From the HAPA, we selected the factors risk perception, outcome expectancies, self-efficacy and planning. To gain more intervention relevant information, the HAPA factors were further disaggregated into several factors as depicted in the RANAS (R(isk), A(ttitudes), N(orms), A(bilities), and S(elf-regulation)) model proposed by Mosler (2012) for water, sanitation and hygiene issues in developing countries.

For risk perception, perceived vulnerability and severity were considered. Perceived Vulnerability is a person’s subjective perception of his or her risk of contracting a particular condition or illness, and perceived severity is a person’s perception concerning the seriousness of the consequences of contracting a particular condition or illness (Brewer et al., 2007).

According to Schwarzer (2008), outcome expectancies can be partitioned into social, emotional and physical components. For the social influences, several researchers have proved the usefulness of distinguishing between descriptive and injunctive norms (Conner & Sparks, 1996; Sheeran & Orbell, 1999). The descriptive norm expresses perceptions about which behaviors are typically performed. The injunctive norm reflects perceptions about which behaviors are typically approved or disapproved (Cialdini, 2003; Schultz et al., 2007).

Corresponding to the emotional and physical components of the HAPA (Schwarzer, 2008), research has shown that it is useful to distinguish between affective attitudes (e.g. enjoyable/unenjoyable) and instrumental attitudes (e.g. beneficial/harmful) towards behavior (Lawton, Conner, & Parker, 2007; Conner, Rhodes, Morris, McEachan, & Lawton, 2011).

Self-efficacy, another component of the HAPA (Schwarzer, 2008), was taken into account in the form of action self-efficacy, maintenance self-efficacy and recovery self-efficacy. Self-efficacy is described as the belief in one's capabilities to organize and execute the course of action required to manage prospective situations (Bandura, 1997).

The HAPA (Schwarzer, 2008) specifies action planning and coping planning as volitional factors. Action planning is the specification of 'when', 'where', and 'how' the action shall take place, whereas coping planning is defined as the presumption of possible barriers and the invention of ways to overcoming them (Schwarzer, 2008). Action planning is defined as the formation of plans to initiate a new behavior. Therefore, action planning was excluded because it is only relevant for parts of our target population––people who are not yet drinking any arsenic-safe water.

Additionally, several researchers have shown that the strength of the commitment to behavior execution will modulate the effect of this event (e.g. Gollwitzer, 1999; Tobias, 2009).

Several publications have shown that factors in the RANAS model influence behavior in the water and sanitation sector in developing countries. For solar water disinfection (SODIS) see Heri and Mosler (2008) in Bolivia, and Kraemer and Mosler (2010) in Zimbabwe; for hygiene behavior see Graf, Meierhofer, Wegelin, & Mosler (2008) in Kenya; for using arsenic-free deep tube wells see Mosler, Blöchliger, & Inauen (2010) in Bangladesh.

Besides the compilation of most potential behavior change predictors, a particular strength of the RANAS model is that it links specific factors to behavior change techniques (BCTs). In addition to simply selecting the theoretically based factors, Mosler suggests an evidence-based approach, i.e. to intervene on behavioral predictors that are most likely to promote behavior change in the target population (Mosler, 2012). In brief, using intervention factors with the highest improvement potential is suggested, i.e. factors with high predictive power as well as low mean values in the target population. In conclusion, the most effective interventions should be: (a) based on behavioral determinants of sound psychological theory; and (b) based on the assessment of the factors with highest improvement potential with regard to the target population.

This procedure was adopted for the present study. In the first part, the behavior change factors with the greatest improvement potential for promoting switching to arsenic-safe wells will be identified. Interventions will then be derived from these results to target the identified factors. In the second part of the study, these interventions will be combined with risk information and compared to an information-only control condition regarding their efficacy to promote behavior change in a cluster-randomized controlled trial. Thereby, the assumption will be tested that theory-based and evidence-based interventions increase the effects of commonly applied informational interventions to promote the use of arsenic-safe water sources.

Part 1:
Developing interventions by identifying psychological factors related to arsenic-safe water consumption

In this part of the study, theory-based and evidence-based interventions to increase the use of arsenic-safe wells are developed by identifying the RANAS factors that are related to the use of arsenic-safe wells.

Methods

A cross-sectional survey was conducted in November 2010 with randomly selected households in Shivalaya and Harirumpur, both sub-districts of Manikganj district, Bangladesh. Arsenic contamination rates in these areas are around 50 percent, making *well-switching* a simple and no-cost mitigation option. Well-switching refers to switching from using an arsenic-contaminated tubewell (usually painted red) to sharing the arsenic-safe tubewell (usually painted green) of a neighboring household.

Participants and procedures

Criteria for study participation were: (a) being at risk of drinking arsenic-contaminated water (i.e. having an arsenic-contaminated tubewell or, for non-owners of tubewells, collecting or having previously collected water from a contaminated well); and (b) having access to a neighboring arsenic-safe tubewell.

We first determined the broader areas of the surveys by selecting three unions (one sub-district has approx. 10 unions): Arua, Ulail and Balla. The unions had to be geographically separated from one another to avoid information contamination in the controlled trial later. We randomly selected a total of 12 villages within the study areas (villages with < 30 households were excluded).

A team of 10 professional Bangladeshi interviewers was recruited to conduct the survey. The interviewers were extensively trained in a five-day workshop to conduct structured face-to-face, one-hour long interviews. Particular importance was paid to the rehearsal of language in order to certify that each interviewer used the same vocabulary to explain the questions in an easily understandable manner for the rural participants. During the survey, a quality-control team answered any uncertainties the interviewers had and ensured the completeness of the questionnaires.

Households were randomly selected with the random-route method (Hoffmeyer-Zlotnik, 2003). For a given household, the interviewers first asked to speak to the person responsible for collecting drinking water (usually a woman). Then interviewers assessed whether the household met the above stated inclusion criteria. If yes, fully informed consent was obtained prior to conducting the interview. As is usually the case for survey research in rural low-income countries (e.g. Mosler et al., 2010), refusal was minimal, and only eight persons (2%) refused to participate. In total, 379 households were interviewed. The vast majority of the participants were female (355, 93.7%), and the average age was 37.3 (*SD* = 11.8). About half of the respondents were literate (191, 50.4%) and had an average of 3.6 years of formal education (*SD* = 3.9). The mean monthly household income was 5228 Bangladeshi Taka (BDT; app. 63 US$; *SD* = 4211 BDT).

Questionnaire

A structured questionnaire was developed and translated from English into Bengali. Re-translation into English revealed translation difficulties with some questions. These were resolved in round table discussions before and after the pre-test.

The questionnaire contained questions regarding water consumption, the behavioral determinants and sociodemographic characteristics.

Water consumption. Participants were asked how many vessels of which water source they collected for drinking on a typical day during the week preceding the survey. Because all respondents either collected all water from safe sources or all water from contaminated sources in the week prior to the survey, the final outcome was use (=1) or non-use (=0) of arsenic-safe water for drinking.

Knowledge. This was assessed with a set of 18 ‘yes-no’ questions. The questions were concerned with knowledge of which water sources contained arsenic, whether contaminated water was safe to drink, which medical conditions could be caused by arsenic and tasks for which it was okay to use arsenic contaminated water. Furthermore, respondents were asked whether they knew the location of a safe water option in their village, whether it was safe to drink from a green-colored tubewell, whether arsenic can be removed by boiling and to name water sources that were free from arsenic. Each correct answer was assigned one point. In the end, all points were added to the score and transformed into the standardized value range of 0 to 1.

All other psychological constructs were measured with several items each on Likert scales (five-point for unipolar items and nine-point for bipolar items), which were averaged. To ensure understanding of the questions, a hierarchical procedure was applied. Participants were first asked to choose one of three answer categories (e.g. rather like, rather dislike, rather neutral). Then participants were offered a more detailed response options in the category they had chosen (e.g. dislike very much, dislike, rather dislike). Example questions for each construct of the RANAS model are presented below.

Vulnerability. Three items were used to assess vulnerability. Participants were asked how high or low the chances were that they or someone in their family would develop arsenicosis, and how high their chances were of developing arsenicosis compared to persons of their sex and age (- 1 = very low to 1 = very high; Cronbach’s Alpha = .84).

Severity. This was measured using three items. Participants were asked, ‘Imagine that you contracted arsenicosis, how severely would it impact your life in general/your social life/your economic situation?’ (0 = not at all severe to 1 = very severe; Cronbach’s Alpha = .87).

Affective attitude. This construct was measured using seven items. Participants were asked, for example, whether they liked collecting water from the safe well, whether they felt ashamed of collecting water from there or whether they liked the water taste (-1 = dislike very much to 1 = like very much; Cronbach’s Alpha = .82).

Instrumental attitude. Perceived expenditure of time and effort were measured using two items. For example, ‘Do you think that collecting water from mitigation option is time-consuming?’ (0 = not at all time-consuming to 1 = very time-consuming; Cronbach’s Alpha = .84). The scale was inverted so low values reflected low attitudes (i.e. high effort/time) and high values reflected favorable attitudes (i.e. low effort/time).

Injunctive norm. This was assessed using three items. People were asked, for example, 'Overall, how much would people who are important to you approve or disapprove of you collecting water from the arsenic-safe water option?' (-1 = they [would] disapprove very much to 1 = they [would] approve very much; Cronbach's Alpha = .75).

Descriptive norm. Two items were used to assess this. Participants were asked to name the number of people outside their families or of their village who collected water from the safe water option (0 = almost nobody to 1 = almost everybody; Cronbach's Alpha = .86).

Action self-efficacy. This was assessed using three items. Participants were asked, for example, how difficult or easy it was to find time to collect water from the arsenic-safe well (-1 = very difficult to 1 = very easy; Cronbach's Alpha = .94).

Maintenance self-efficacy. Participants answered three questions related to how confident they felt about collecting water from the safe option 'even if they had to walk a long distance/the safe option was broken/they did not feel like collecting water' (0 = not at all confident to 1 = very confident; Cronbach's Alpha = .89).

Recovery self-efficacy. Three items assessed people's recovery self-efficacy. People were asked, for example, 'Imagine that you stopped going to collect water from the safe well for several days. How confident are you to start collecting water from the safe option again?' (0 = not at all confident to 1 = very confident; Cronbach's Alpha = .93).

Coping planning. This was measured with three items. Participants were asked, for example, 'Have you made a detailed plan of what to do when the arsenic-safe option is broken?' (0 = no detailed plan at all to 1 = very detailed plan; Cronbach's Alpha = .85).

Commitment. Three items were used to assess this. Participants were asked how important was it for them to collect water from the safe option, how committed they felt to collecting water from the safe well, and how annoyed they felt if they forgot to collect water from there (0 = not at all to 1 = very important/committed/annoyed; Cronbach's Alpha = .76).

Data analysis

All calculations were computed with IBM SPSS Statistics 20.0. Key behavioral factors were determined by logistic regressions of the use and non-use of arsenic-safe water for drinking. Outliers with residuals greater than two standard deviations were excluded from the model. In addition, cases with missing values were excluded.

Results

One hundred and four (27.4%) participants reported using neighboring arsenic-safe shallow tubewells for drinking. The frequencies of all psychological factors are presented in Table 8.

The survey revealed medium knowledge about arsenic and arsenicosis. Despite this, perceived vulnerability regarding arsenicosis, on average, was rather low. Severity of the consequences of developing arsenicosis was consistently rated high. Participants, on average, reported rather low affective attitudes and high instrumental attitudes. Regarding social norms, participants stated medium strength beliefs that collecting water from neighboring safe wells was expected by others (injunctive norm). On average, participants reported that some others were collecting water from arsenic-safe neighboring wells (descriptive norm). The mean rating of the difficulty of the task of collecting arsenic-safe water was near zero (neither easy nor difficult). People reported rather high confidence in their ability to collect water from the arsenic-safe water options even if barriers arose (maintenance self-efficacy) or if they stopped collecting water from there for a while (recovery self-efficacy). Despite rather high self-efficacy, participants’ coping plans were not clearly defined. Finally, people were only rather committed to collecting arsenic-safe water.

Results of the logistic regression revealed that the psychological factors predicted the use and non-use of neighboring arsenic-safe shallow tubewells very well (Table 8). The strongest predictors of the use and non-use of neighboring arsenic-safe shallow tubewells were the descriptive norm, commitment, vulnerability (unexpectedly negatively associated) and recovery self-efficacy. Furthermore, higher maintenance self-efficacy, instrumental attitudes, and injunctive norms were in line with the use of safe tubewells, but, unexpectedly, lower affective attitudes were negatively related.

Discussion

The results of Part 1 of this research indicate that the use of neighboring arsenic-safe shallow tubewells is much more likely for people with higher commitment, stronger descriptive norms and higher self-efficacies. Furthermore, vulnerability was strongly associated with using arsenic-safe wells. However, the direction of the relationship was unexpectedly negative. The most likely explanation of this finding is reverse causality–– people who consume arsenic-safe water consequently feel less vulnerable to developing arsenicosis. Longitudinal research should investigate this more conclusively.

Table 8. *Descriptive statistics and logistic regression of the use of neighboring arsenic-safe shallow tubewells on psychological factors (n = 363)*

Factors	*M*	*SD*	*r*	*B*	*OR*	95% CI *OR* *LL*	95% CI *OR* *UL*	*p*
Knowledge	0.50	0.16	-0.03ns	0.52	1.68	0.04	69.98	.786
Vulnerability	-0.12	0.53	-0.57***	-7.67	0.00	0.00	0.01	.000
Severity	0.82	0.13	0.00ns	-2.56	0.08	0.00	16.33	.349
Affective attitude	0.33	0.31	0.27***	-3.10	0.05	0.00	0.49	.011
Instrumental attitude	0.53	0.29	0.30***	3.73	41.70	1.19	1463.25	.040
Injunctive norm	0.47	0.36	0.20***	2.79	16.22	1.54	170.78	.020
Descriptive norm	0.42	0.23	0.42***	8.55	5148.83	86.37	306929.69	.000
Action self-efficacy	0.09	0.55	0.38***	-0.13	0.88	0.16	4.91	.883
Maintenance self-efficacy	0.45	0.25	0.50***	4.60	99.89	1.06	9458.11	.047
Recovery self-efficacy	0.51	0.25	0.47***	7.60	1996.73	14.64	272255.54	.002
Coping planning	0.22	0.18	0.34***	-2.54	0.08	0.00	3.17	.178
Commitment	0.40	0.26	0.45***	8.17	3518.69	73.32	168855.99	.000
Constant				-18.30	.000			.000

Note. r = Pearson correlations with the use of arsenic-safe water; *OR* = odds ratio; *CI* = confidence interval of the odds ratio; *LL* = lower limit; *UL* = upper limit. All variables ranged from 0 to 1, except the bipolar variables (vulnerability, affective attitude, injunctive norm, action self-efficacy) that ranged from -1 to 1. Use of arsenic-safe water option was coded as 1, non-use was coded as 0.

Nagelkerke R^2 = .894; correct classifications 95.3%. ns = $p > 0.05$; *** = $p < 0.001$.

To determine the highest impact potential of a behavior change intervention, we followed Mosler’s (2012) suggestion to consider both the strength of association with the target behavior and the means of the psychological factors in the population. The factors with highest behavior change potentials with regards to the means ($M < 0.50$) were vulnerability, affective attitude, injunctive norm, descriptive norm, action self-efficacy, maintenance self-efficacy, coping planning and commitment (see Table 8). Combining the information regarding the means and the strength of association with using arsenic-safe wells, the following three factors emerged as having the highest impact potential in behavior change intervention: commitment, the descriptive norm and self-efficacy. In addition, the affective attitude may have an impact; however, the negative association of using arsenic-safe wells in the regression suggests complex interactions with other psychological factors. We, therefore, did not target this factor. Similarly, we did not target vulnerability due to the unclear causality of the relation of this factor with the use of arsenic-safe wells.

The RANAS model suggests a set of BCTs that can modify each of the determinants identified above (Mosler, 2012). To increase commitment, we selected prompts and implementation intentions. Prompts are simple reminders that increase the accessibility of the target behavior (Tobias, 2009). Implementation intentions are detailed plans that link situations with actions. Both BCTs are low cost and have been shown to effectively change a series of health-related and other behaviors (e.g. Adriaanse, Vinkers, De Ridder, Hox, & De Wit, 2011; Cox, Cox, & Cox, 2005; Tobias, 2009). To enhance descriptive and injunctive norms, the public commitment intervention was selected from the norm BCTs (Mosler, 2012). Group interventions are frequently and popularly applied in Bangladesh. Furthermore, public commitment not only highlights norms, but should increase personal commitment also. Finally, Mosler (2012) suggests that maintenance self-efficacy and recovery self-efficacy can be enhanced by coping planning. However, in order not to overload this intervention, these factors were targeted in a second intervention phase that will be published elsewhere. In the following, the efficacy of the developed interventions in comparison with an information-only control will be tested.

Part 2: Testing the effectiveness of theory-based and evidence-based interventions

To test the assumption that the interventions, which were developed on the basis of theory and evidence, are more effective in promoting well-switching than commonly used informational interventions, we conducted a cluster-randomized controlled trial. It was hypothesized that information would render smaller behavior change effects than information combined with reminders (H1), information combined with reminders and implementation intentions (H2) and all interventions combined with public commitment (H3). Furthermore, it was assumed that more well-switching will be observed in the condition that combined implementation intentions, reminders and information compared to reminders and information alone (H4). Finally, we hypothesized that the combination of all interventions with a public commitment will lead to a greater proportion of well-switching than information, reminders and implementation intentions (H5).

Methods

The cluster-randomized controlled trial was conducted from November 2010 to April 2011 in Shivalaya, Bangladesh. Four clusters of two to four villages were randomly assigned to an information-only control group or to one of three theory-based intervention groups: (a) information and reminders; (b) information, reminders and implementation intentions; (c) information, reminders, implementation intentions and public commitment.

Clusters and participants

In principal, participants of the first part of this study were the same as in the second part, and the assessment described in Part 1 formed the baseline of the trial. However, one additional inclusion criterion for the randomized controlled trial was non-use of arsenic-safe water at baseline. Consequently, 105 users were excluded. To increase sample size, an additional four villages adjacent to the selected villages were included, and 96 additional randomly selected households were surveyed at the baseline. In total, 370 households in 16 villages were included in the trial (see Figure 6 for the participants flow). Most participants were female (350, 94.6%), and were on average 36.6 years old (*SD* = 12.2). One hundred eighty-three were literate (49.5%) and had attended school for 3.6 years (*SD* = 4.0). The mean monthly household income was 6670 BDT (app. 80 US$; *SD* = 3610 BDT).

Interventions

All interventions were delivered by health promoters of a local non-government organization, CCDB (Christian Commission for Development in Bangladesh). They each received 4000 BDT (app. 50 USD) for their services during this one-month intervention. The five female promoters (18 to 25 years old) lived in the study areas and were trained by the first author and a local collaborator to correctly provide the interventions. These were delivered in February 2011. At each visit, promoters obtained fully informed consent. Thereafter, promoters conducted the intervention session, which lasted from 20 to 60 minutes depending on the intervention condition (each BCT required approx. 20 minutes). Participants in the public commitment condition were also invited to join the commitment session held in their village two weeks after the promoter’s visit.

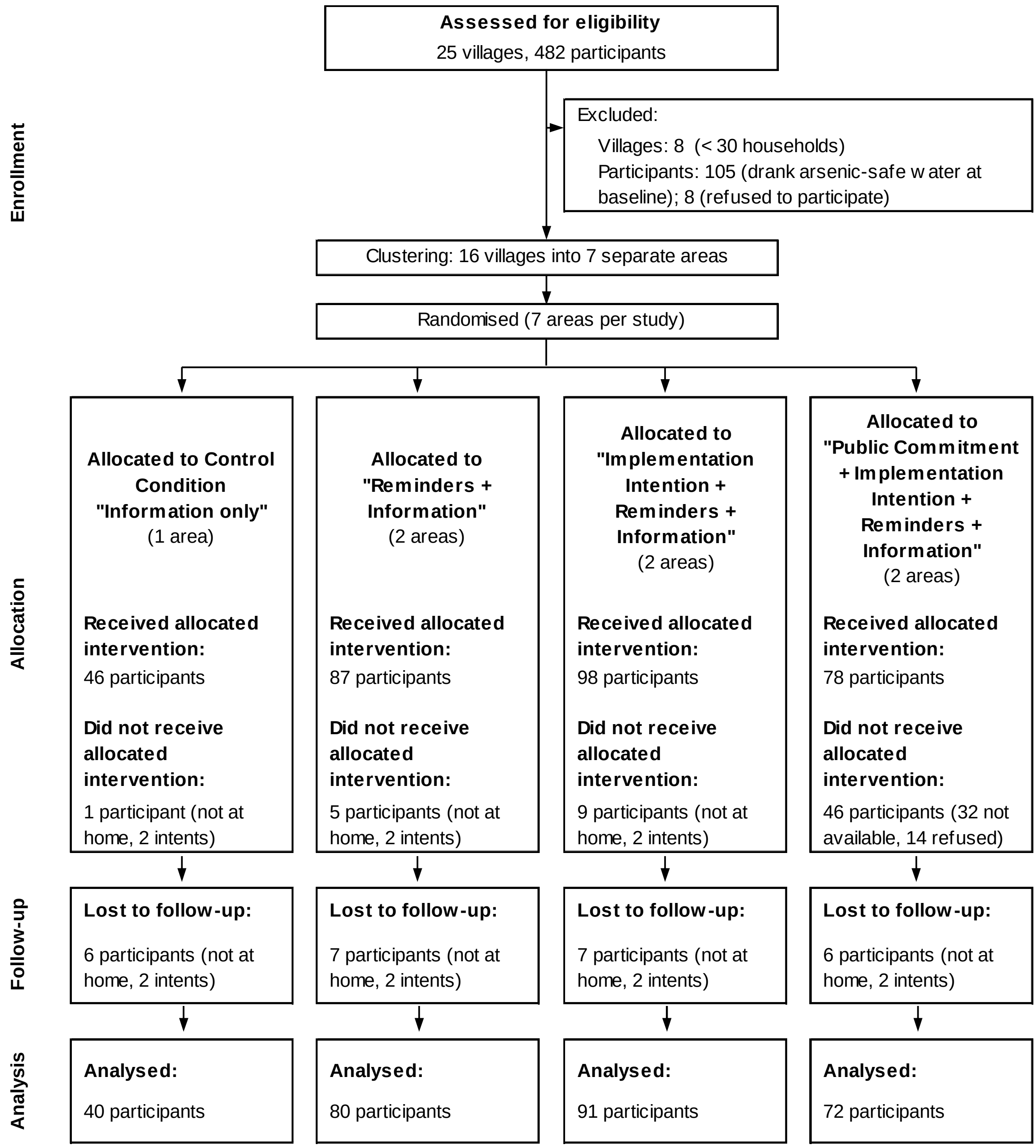

Figure 6. Participant flow through the cluster-randomized trial.

A local supervisor was employed for quality control and to assist the promoters. The elements of the interventions are described below (intervention manuals can be found at http://www.eawag.ch/forschung/siam/schwerpunkte/soziale_systeme/Beh_Change_Guideline_2012.pdf). Note that all materials were designed so they could also be understood by illiterate participants.

Information on arsenic, arsenicosis and arsenic-safe drinking water options. This element of the intervention was the control condition and the basis of the three theory-based intervention arms. The promoters explained the following content to the participants by demonstrating a booklet with pictograms and photographs. First, promoters informed participants about arsenic in shallow tubewell water. Second, it was explained that arsenic can have adverse health effects, and these effects were described. Finally, participants were told where arsenic-safe water can be found in their communities (green-marked shallow tubewells), and in general (all major arsenic-safe water sources available in Bangladesh).

Reminders. A set of two reminders was developed––a poster and a tag. The poster was designed to remind participants in the key situation (just before their drinking water was finished) to collect their water from the safe option. It depicted an almost empty *kalosh* (local vessel for water collection, (pl. *kolshi*)) and a woman who goes to collect water from a green-marked tubewell instead of a red-marked one, which was crossed out.

The tag was developed to remind participants not to collect drinking water from the red-marked tubewell. It contained pictograms showing the purposes for which the water should not be used: drinking directly, boiling and then drinking or cooking. Furthermore, the tag displayed the purposes for which the water can be used (e.g. bathing, washing dishes).

Promoters first explained the contents of the poster and then installed it at the place within the household where participants kept their kolshi. Thereafter, promoters explained the contents of the tag and installed it at the arsenic-contaminated tubewells, which the participants reported to use.

Implementation intention. Implementation intentions are specific plans for where, when, and how to perform a behavior (Gollwitzer & Brandstätter, 1997). It is a special challenge to conduct these interventions for people with low literacy who are not used to living by the clock. We used pictograms with typical tasks during the day for the ‘when’ part of the plans (e.g. sunrise, breakfast, bathing, etc.). First, promoters asked participants how many times a day they would have to collect water at their neighbor’s arsenic-safe tubewell. Then participants were asked to specify a situation before or after which it would be best for them to collect water (e.g. before preparing lunch). Then, participants named a specific neighbor’s green-marked tubewell from where they committed to collecting their drinking water. Subsequently, they specified how many kolshi they would collect each time they went and for which purpose (drinking, cooking or both). In the end, participants were asked to repeat the plan out loud after the promoter, to sign the implementation intention form by thumbprint and to keep it safe.

Public commitment. Participants in this condition were invited by the promoter to join the public commitment session that was held in their respective villages approximately one week after the promoter visit. The sessions were part informational and part commitment. First, using posters, a team of two promoters and the supervisor again explained the information about arsenic, arsenicosis and arsenic-safe drinking water to the group of participants. Thereafter, participants were asked to commit themselves to only drink arsenic-safe water from now on. The participants who committed were asked to read their implementation intentions to the group. At the end of the two-hour session tea and biscuits were offered.

Data collection

Data during the follow up in April 2011 were collected by face-to-face interviews as described in Part 1. Special care was taken to interview the same participants as were interviewed during the baseline. Again, the final outcome was the use (=1) or non-use (=0) of arsenic-safe water for drinking.

Data analysis

First, a randomization check was performed by comparing intervention and control groups on all psychological factors at baseline and sociodemographic variables by analyses of variance (ANOVA) or Chi^2 Tests (for dichotomous measures). For the former, the Welch statistic was used due to inhomogeneous variances. Omega squared (ω^2) was computed as a measure of effect size. To test for potential biases due to attrition, dropouts were compared in order to study households on all baseline measures with Independent Samples T Tests and Chi^2 Tests, respectively. In the main analyses, logistic regressions of the use or non-use of arsenic-safe drinking water were conducted. Intervention dummy variables (each intervention vs. control group) served as independent variables. Variables with significant baseline differences between intervention groups were entered as covariates.

Results

Randomization check

No baseline differences between intervention groups were found for knowledge, severity, instrumental attitude, action self-efficacy, recovery self-efficacy, commitment, income, education or literacy. However, significant effects were found for vulnerability ($F[3,125.549] = 16.13$, $p < .000$, $\omega^2 = .13$), affective attitude ($F[3,128.258] = 8.53$, $p < .000$, $\omega^2 = .08$), injunctive norm ($F[3,130.776] = 4.96$, $p = .003$, $\omega^2 = .04$), descriptive norm ($F[3,126.438] = 7.01$, $p < .000$, $\omega^2 = .05$), maintenance self-efficacy ($F[3,126.226] = 5.391$, $p = .002$, $\omega^2 = .04$), coping planning ($F[3,131.566] = 4.03$, $p = .009$, $\omega^2 = .03$), age ($F[3,129.523] = 3.24$, $p = .024$, $\omega^2 = .02$) and distance to an arsenic-safe well ($F[3,129.116] = 3.43$, $p = .019$, $\omega^2 = .02$). Although most effects were small, these variables were entered as covariates in the main analysis.

Attrition check

In total, 61 households did not receive the allocated interventions, and 26 households were out of reach during the follow up (see Figure 6). No differences between dropouts and included households were found for knowledge, vulnerability, severity, instrumental attitude, the self-efficacies, coping planning, age, income, education, or literacy. However, dropouts displayed significantly higher affective attitudes ($t[180] = -3.67$, $p < .000$, $r = 0.17$), higher injunctive norms ($t[182] = -2.21$, $p = .028$, $r = 0.16$), significantly lower descriptive norms ($t[171] = 2.35$, $p = .020$, $r = 0.18$) and lower commitment ($t[149] = 2.04$, $p = .044$, $r = 0.16$). All effects were small. Finally, the number of dropouts differed significantly between the intervention and control groups ($\chi^2 = 35.31$, $df = 3$, $p < .000$). In the public commitment condition, the dropout rate was particularly high (52, 60%), but it was small in the other groups (implementation intention: 18%; reminders: 14%; control: 8%).

Main analysis

In the information-only control condition, seven participants (18%) had switched to an arsenic-safe neighboring shallow tubewell at follow up. In the intervention group with information and reminders, 35 (44%) had switched. Sixty households (66%) with information, reminders, and implementation intentions had switched. Unexpectedly, only 13 households (18%) who had received all the interventions plus public commitment had switched to safe water. Logistic regressions of the use of arsenic-safe drinking water at follow up supported hypotheses one and two. Compared to information only, participants with additional reminders were 3.10 times more likely to switch to an arsenic-safe water source ($B = 1.13$, $SE = 0.50$, $df = 1$, $p = .024$), whereas participants with an additional implementation intention were 8.05 times more likely to switch ($B = 2.09$, $SE = 0.56$, $df = 1$, $p < .000$). The additional implementation intention tended to increase the likelihood of well-switching compared to reminders and information alone (Exp(B) = 2.09; B = 0.74, SE = 0.38, df = 1, p = .052). However, contradicting the third and the fifth hypotheses, participants with all interventions and a public commitment were not more likely to switch to an arsenic-safe well than participants in the control condition (Exp(B) = 1.48; B = 0.39, SE = 0.79, df = 1, p = .620), and were less likely to switch than households in the implementation intention condition (Exp(B) = .136; B = -2.00., SE = 0.42, df = 1, p < .000). None of the covariates achieved significance in any of the analyses.

Discussion

In a cluster-randomized controlled trial, theory-based and evidence-based interventions were compared to an information-only control condition regarding their effectiveness in promoting the use of arsenic-safe wells. In line with our hypotheses, more people switched to arsenic-safe wells when theory-based and evidence-based interventions were delivered in addition to risk information. In particular, implementation intentions when combined with information and reminders proved effective in promoting well-switching. An additional public commitment intervention, however, was not more effective than information alone. This result is surprising, because it seems that the commitment session had a detrimental effect on the effects of the other interventions. Possible reasons for this may be that social influence processes may have taken place during the sessions, e.g. opinion leaders that were opposed to collecting from neighboring safe wells may have been present in the sessions. In addition, perhaps the commitment session was conducted too soon after the promoter’s visit and may have caused reactance. Furthermore, in line with this assumption is the fact that non-attendance of the public commitment sessions was high, indicating that only the higher motivated participants attended these sessions. Making their already formed commitments public may have caused further reactance.

Overall discussion

We argued that developing behavior change interventions based on psychological theory and evidence will enhance the effects of a risk information intervention to encourage switching to arsenic-safe wells. In a first part, this research revealed that commitment, the descriptive norm, self-efficacy, as well as perceived vulnerability are the main predictors of the probability of using neighboring arsenic-safe wells. Interventions developed to target these factors increased behavior change effects of a risk information intervention by up to 48 percent. The most successful intervention to promote well-switching were implementation intentions in combination with information and reminders delivered by local health promoters. Public commitment had an unexpected negative effect on people switching to arsenic-safe wells. Group-based interventions should, therefore, be applied with caution until further studies identify when, for whom and why group interventions may be beneficial or detrimental.

Regarding the factors that were associated with using arsenic-safe wells, the results of this study highlight the importance of descriptive norms and self-efficacy. This is in line with previous research on safe water consumption that demonstrated the importance of the perception that safe water collection is typical in the community and that people are confident of being able to collect safe water in the long term (Mosler et al., 2010; Huber et al., 2012). Furthermore, commitment was highly predictive of arsenic-safe water use. This finding supports the assumption that this is an important factor to consider in this context and also perhaps for other behaviors (Tobias, 2009). This notion is further underlined by the high behavior change impact of interventions that targeted commitment strengthening.

Overall, the medium to strong increase in the behavior change effect of the theory-based and evidence-based interventions support the usefulness of an applied approach of intervention development. This strengthens the assumption that theory is useful for intervention development (Michie & Johnston, 2012). It shows that the psychological factors that need to be modified in the intervention can be identified by considering whether theoretically proposed factors are associated with the target behavior and how they are distributed in the population in need of change. Without evidence from a baseline assessment, any other factor from the theoretical model could have been targeted in the intervention, e.g. severity. However, such an intervention would have produced little effect in this case because most people in the population already rated arsenicosis as severe. Furthermore, severity was not significantly associated with using arsenic-safe wells.

Of the applied interventions, implementation intentions in combination with information and reminders produced the strongest behavior change effects. This is in line with the vast literature that documents the strong effects of implementation intentions on changing a series of behaviors (e.g. Adriaanse et al., 2011; Cox et al., 2005; Tobias, 2009). Particularly encouraging, with regards to behavior change in developing countries, is the fact that these low-cost implementation intentions were also effective in a format tailored to illiterate persons. Regarding the question of cost effectiveness of interventions, it would be beneficial to investigate whether the behavior change effects are altered if implementation intentions are applied without the reminders and risk information. More important, future research should focus on the mechanisms of change, i.e. to investigate whether the interventions indeed changed behavior by modifying the proposed psychological factors. Finally, it is important to identify possible moderators of these intervention effects.

The fact that the interventions were developed based on a cross-sectional investigation of factors associated with the use of arsenic-safe wells may be seen as a limitation of this study. Certainly, causality of the relationship between the psychological factors and behavior cannot be ascertained by these designs. It may, therefore, be fruitful to apply a longitudinal design for assessing the psychological factors and predicting the target behavior. However, the additional time and resources required for such a longitudinal intervention development period must be considered. Future studies should compare the cost effectiveness of interventions developed from cross-sectional data and panel data.

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Conflicting interests

None declared. This study was conducted in strict compliance with the ethical principles of the American Psychological Association (APA), the Declaration of Helsinki and with consent of the ethics review of the University of Zurich, Switzerland.

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Chapter V

Promoting safe water consumption by increasing commitment strength: A longitudinal mediation analysis

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A similar version of this chapter is

in preparation for publication

(Inauen et al., submitted)

Abstract

Objective: To investigate whether increasing commitment strength can promote switching to arsenic-safe wells. ***Methods:*** Randomly selected households (N = 226) of Monoharganj, Bangladesh, in seven geographically separate areas, whose members were drinking arsenic-contaminated water at baseline and had access to arsenic-safe wells, participated in this cluster-randomized trial. The seven areas were randomly allocated to one of three theory-based intervention conditions or an information-only comparison. Water consumption behavior, variables of the Theory of Planned Behavior (TPB), commitment strength, and participants' sociodemographic characteristics were assessed at baseline and at three-month follow-up by means of structured face-to-face interviews. A longitudinal mediation model was estimated to quantify the role of the psychological variables in changing to safe water consumption. ***Results:*** Changes in commitment strength significantly increased the explanatory power of the TPB to predict well-switching at follow-up. Behavior change techniques (BCTs) targeted at increasing commitment strength—public self-commitment, implementation intentions, and reminders—increased the behavior change effects of an informational intervention by up to 50%. More importantly, mediation analyses confirmed that the BCTs indeed increased well-switching by increasing commitment strength. ***Conclusion:*** The commitment to exhibit a behavior is an important construct to consider in water- and health-related behavior change, and it may be important for other health behaviors as well. BCTs that alter commitment strength proved highly effective at enhancing the behavior change effects of risk information to improve water consumption behavior.

Keywords: Bangladesh, behavior change, commitment strength, implementation intention, theory-based intervention

Introduction

Nearly 800 million people lack access to safe drinking water (UNICEF & WHO, 2012). In fact, unsafe drinking water (jointly with a lack of sanitation and hygiene) accounted for 3.8% of the deaths in low- and middle-income countries in 2004 (WHO, 2009). Besides the provision of affordable, improved water sources, behavior change is vital to ensure safe water consumption and to mitigate water-borne diseases. While early research in this domain was largely qualitative and without theoretical basis (e.g., Hoque et al., 2004; Opar et al., 2007), theory-based psychological research has advanced. Factors from the Protection Motivation Theory (Rogers, 1975; Mosler, Blöchliger, & Inauen, 2010), the Transtheoretical Model (Prochaska & DiClemente, 1983; Kraemer & Mosler, 2011), and the Theory of Planned Behavior (TPB; Fishbein & Ajzen, 2010; Altherr, Mosler, Tobias, & Butera, 2008; Kraemer & Mosler, 2012) have successfully predicted safe drinking water consumption. From such models, theory-based behavior change techniques (BCTs) can be derived to enhance safe water consumption. These are likely to render greater behavior change than interventions built on the common belief that people do not carry out health-protective actions due to a lack of knowledge (cf. Michie & Prestwich, 2010). Besides testing the efficacy of such interventions, it is equally important to investigate their underlying mechanisms (Michie & Abraham, 2004). This can enable the refinement of behavior change interventions and the drawing of inferences about behavior change theory (Michie & Prestwich, 2010).

Predicting behavior change: Motivation and commitment

When initiating a new behavior, such as switching to an alternative water option, motivational factors can be important. A well-evidenced and convincingly parsimonious theory with regard to motivation is the TPB (Fishbein & Ajzen, 2010). In brief, the theory postulates that beliefs about the consequences of a behavior (i.e., attitude), which behaviors are approved by others (i.e., subjective social norm), and the control one has over performing a behavior (i.e., perceived behavioral control [PBC]) form behavioral intentions, which, in turn, jointly with PBC, predict behavior. However, for planning theory-based behavior change, these constructs are quite broad. A fruitful approach for deriving theory-based BCTs is to further specify the factors of the TPB in order to identify modifiable behavioral determinants. Thus, instead of subjective norms, the present study will investigate injunctive and descriptive norms (Ajzen & Fishbein, 2005). The former describe what a person thinks should or should not be done, and the latter represents people’s perceptions of which behaviors are typically performed. Furthermore, the differentiation of affective attitude (emotional beliefs, e.g., finding behavior pleasant or unpleasant) and instrumental attitude (cost-benefit beliefs) has been deemed useful (Ajzen & Fishbein, 2005). Further, risk perception, as the belief about the personal consequences of a potentially health-threatening behavior, presents a further constituent of attitude (Norman & Conner, 2005) that is an important component of many health-behavior models (e.g., the Protection Motivation Theory; Rogers, 1975). However, the construct of intention is not sufficiently informative for deriving theory-based interventions, because it represents an abstract overall motivation to perform a behavior. A more powerful concept seems to be commitment strength, introduced by Gollwitzer (1999).

According to Gollwitzer (1999), commitment strength reflects the actual strength of the decision to display a behavior, which is induced by implementation intentions, that is, simple plans about when, where, and how to exhibit the behavior. Tobias (2009) generalized this concept to cases where there are no implementation intentions; he proposed that the decision to initiate a behavior changes a cognitive intention into a tension state, which affects behavioral performance. Thus, performing the behavior becomes an urge or need, and the person feels satisfaction when performing the behavior and is annoyed when failing to do so. Like Tobias (2009), Mosler (2012) incorporated commitment strength as a behavior change determinant in the Risk, Attitude, Norm, Ability, and Self-Regulation (RANAS) model to change behaviors related to water, sanitation, and hygiene.

Empirical studies have demonstrated that commitment strength is an important predictor of the adoption and maintenance of safe water consumption (Huber & Mosler, 2012; Kraemer & Mosler, 2012; Tamas & Mosler, 2011; Tobias & Berg, 2011), and it may be important for other health behaviors as well. As the most proximal predictor of the described theoretical framework, commitment strength is the most promising of the described factors to target. Therefore, the present study derives interventions to increase commitment strength. If these interventions indeed exert their behavior change effects by changing commitment strength, this will further indicate the construct’s importance in the behavior change process. In any case, more information about the mechanisms of the behavior change interventions studied here will emerge.

BCTs to increase commitment

Although commitment strength has rarely been integrated into behavior change theory as a construct, self-commitment interventions have been applied widely in health psychology (also referred to as behavioral contracts; Abraham, 2012), and in environmental psychology (see Dwyer, Leeming, Cobern, Porter, & Jackson, 1993). “A [self-]commitment is an oral or written pledge or promise to change behavior (e.g., to conserve energy)” (Abrahamse, Steg, Vlek, & Rothengatter, 2005, p. 275). Self-commitment can be either private or public. It is private if the promise to execute behavior is given privately by the individual and public if self-commitment includes the announcement of the pledge to the community (Mosler & Tobias, 2007). Public self-commitment is likely to increase the effects of private self-commitment, because they have been shown to increase injunctive norms (Kraemer & Mosler, 2012). Since the signs of public self-commitment make private behaviors visible to others, they may also increase descriptive norms.

Similar to private self-commitment are implementation intentions (Gollwitzer, 1999). They have proven highly effective in modifying a series of health behaviors, such as reducing excessive alcohol consumption (Hagger, Lonsdale, & Chatzisarantis, 2012). Regarding their mode of operation, it has been shown that implementation intentions do not increase deliberation (Webb & Sheeran, 2008). Instead, they take effect by forming a link between the prospective situation and the behavior, thereby increasing the accessibility of the situation and the association between the situation and the target behavior (Webb & Sheeran, 2008).

With regard to water consumption, reminders have been found to increase commitment to disinfect drinking water (Kraemer & Mosler, 2012). The evidence on the efficacy of reminders to change behavior, however, has been mixed. Differences have been attributed to the characteristics of the reminders and the amount of preparative activities for installing them (Guynn, McDaniel & Einstein, 1998). Guynn and colleagues (1998) concluded that if a reminder is set up in an effective form, there is not much difference between implementation intentions and reminders. Tobias (2009) argued, however, that even optimally dispensed reminders may have varying effects due to differences in commitment strength; in other words, for more strongly committed persons, reminders should have stronger effects.

The Present Study

Arsenic-safe drinking water constitutes the water consumption behavior in this study. Naturally occurring arsenic in ground water poses a great health threat, with approximately 100 million people at risk of drinking water exceeding the WHO guideline of 1 µg of arsenic per liter (Amini, Abbaspour et al., 2008). Chronic arsenic intake can lead to arsenicosis, comprising skin diseases, cancer, cardiovascular diseases, and impaired neurodevelopment in children (Wasserman et al., 2004). In Bangladesh, the most arsenic-affected country in the world, the agencies involved in mitigation have installed safe water options for affected communities and households, including deep tubewells that provide safe water by tapping deeper, arsenic-safe aquifers. Although accompanying awareness campaigns have had some behavior change effects, there is scope for improvement (Johnston & Sarker, 2007). Therefore, augmenting commonly applied informational interventions with theory-based BCTs derived from the above-described theoretical framework should increase the behavior change effects. This research design allows the investigation of the importance of commitment in the behavior change process (cf. Williams, 2010). Moreover, changes in commitment strength should mediate the increased behavior change effects of added theory-based BCTs that target commitment strength as compared to risk information alone.

In summary, this study has two aims. First, the suitability of factors from the TPB, supplemented with commitment strength to predict behavior change for arsenic-safe water will be tested. It is hypothesized that positive changes in the TPB variables can predict switching to arsenic-safe wells (H1a). Furthermore, it is assumed that increased commitment strength will significantly contribute to predicting switching to arsenic-safe wells (H1b), and will significantly increase the explanatory power of the TPB (H1c).

The second and major aim of the study is to investigate the efficacy and the mode of operation of an informational intervention that is augmented with theory-based BCTs that target commitment strength to increase arsenic-safe water consumption. To investigate this, the three BCTs—public self-commitment, implementation intentions, and reminders—were combined with risk information, and health promoters delivered them to the participants. Three theory-based intervention arms were implemented. With each condition, more theory-based BCTs were added, to increase commitment-enhancing effects and, thus, to achieve maximal behavior change. To maintain a low-cost intervention, the simplest theory-based BCT addition of the informational intervention (i.e., reminders) was implemented first. In the second arm, implementation intentions were added to the reminders, and finally, public self-commitment, the most laborious and costly of the three BCTs, was added to all other BCTs. All theory-based intervention arms were compared to an information-only condition in a cluster-randomized trial. Regarding behavioral effects, it is hypothesized that the theory-based BCTs-augmented interventions more effectively promote switching to arsenic-safe wells than the information-only comparison intervention (H2). Regarding the mechanisms of the interventions, it is hypothesized that the theory-based BCTs-augmented interventions, compared to the information-only condition, will promote well- switching by changing commitment strength toward arsenic-safe water collection (H3a). In addition, normative effects are assumed for public self-commitment. Therefore, it is hypothesized that injunctive norms (H3b) and descriptive norms (H3c) will positively mediate the behavior change effects of the third theory-based intervention condition including public self-commitment.

Methods

A cluster-randomized controlled trial was conducted from December 2010 to April 2011 in Monoharganj, a sub-district of Comilla, Bangladesh. Four clusters of two to four villages each were randomly assigned to an information-only comparison condition (subsequently referred to as inf) or to one of three theory-based intervention conditions, where theory-based BCTs were added to the informational intervention: (a) reminders, and information (rem+inf); (b) implementation intentions, reminders, and information (imp+rem+inf); and (c) public self-commitment, implementation intentions, reminders, and information (pub+imp+rem+inf).

Clusters and participants

The criteria for study participation were (a) drinking water from an arsenic-contaminated tubewell at baseline and (b) having access to an arsenic-safe deep tubewell. The first criterion was assessed by self-report, and the second criterion was fulfilled by the selection of villages where at least one functional arsenic-safe deep tubewell was available.

As the broader study area, three unions of Monoharganj were randomly selected: Hasnabad, Jhalam Uttar, and Maisatua. Of the 57 villages in these unions, 38 were excluded due to the ongoing behavior change activities of the researchers’ non-government partner organization, Village Education Resource Center (VERC). Of the 19 assessed villages, four more were excluded due to non-functional deep tubewells (see Figure 7). The 15 remaining villages were grouped into seven geographically separate clusters that were randomly assigned to the information-only comparison or one of the three theory-based intervention conditions.

Overall, 340 randomly selected households were interviewed at baseline, of which 90 did not receive the allocated interventions, and 24 were not available for follow-up (see Figure 7). Thus, in total, 226 households were assessed both at baseline and follow-up, had received the allocated interventions, and were subsequently analyzed. The vast majority of the participants were female (223, 98.7%), and the average age was 35.8 years (SD = 12.0). About two-thirds of the respondents were literate (155, 68.6%) and had received an average of 5.4 years of formal education (SD = 3.8). The median monthly household income was 8,000 Bangladeshi Taka (BDT; approximately 96 USD).

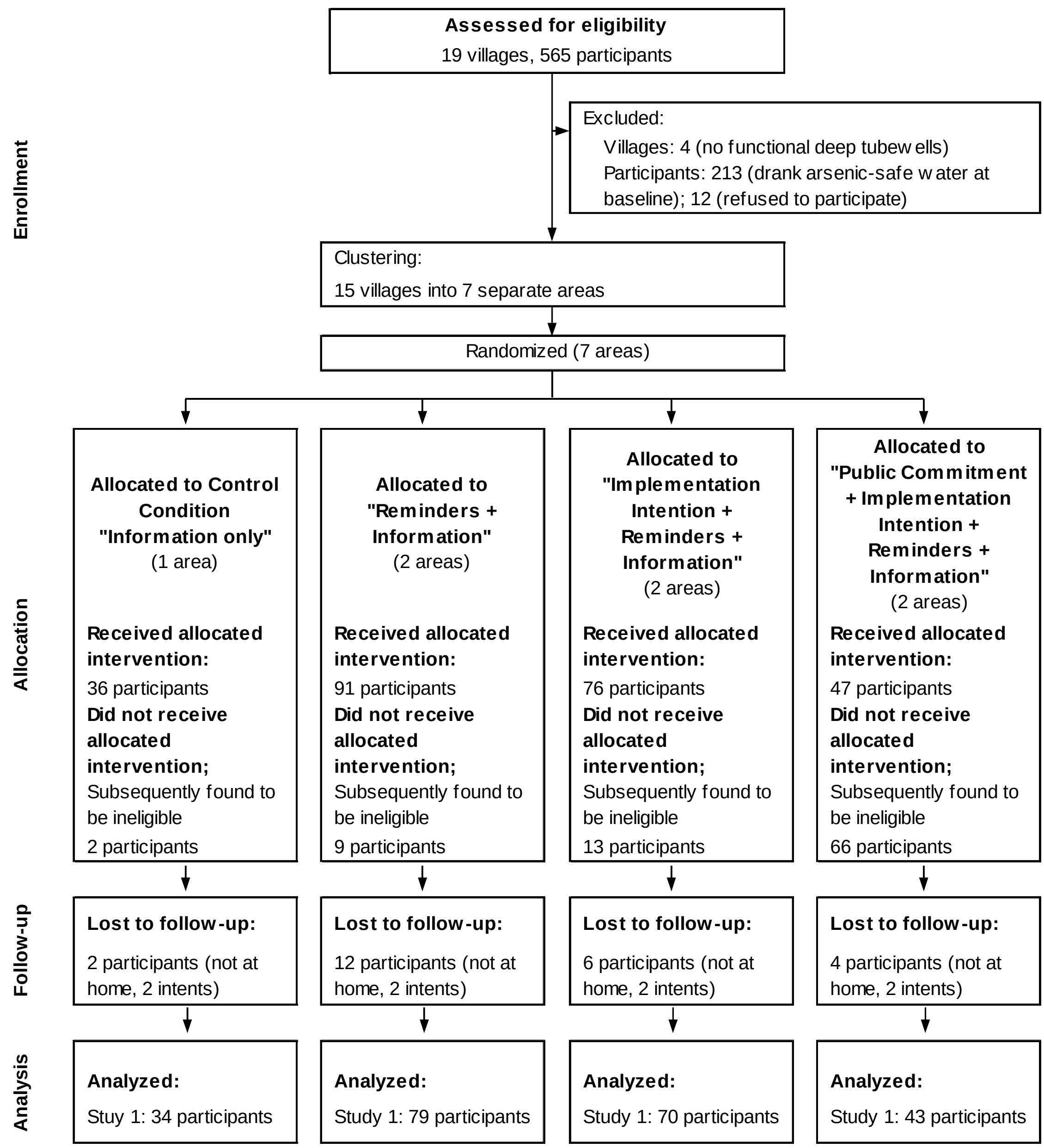

Figure 7. Participant flow through the cluster-randomized trial.

Measures

A structured questionnaire was developed, pretested, and refined in a large pilot survey in Bangladesh for use in the present study. The questionnaire items concerned water consumption, the TPB constructs, risk perception, commitment strength, and sociodemographic characteristics. All psychological constructs were the averages of several items derived from the literature (for details, see Mosler, 2012) and adapted to the water consumption context. The response options were Likert scales (5-point for unipolar items and 9-point for bipolar items). To ensure the participants' comprehension of the questions, a hierarchical procedure was applied: the participants were first asked to choose one of three answer categories (e.g., rather like, rather dislike, rather neutral), and then they were offered more detailed response options in the category they had chosen (e.g., dislike very much, dislike, rather dislike). Example questions for each construct and internal consistencies (baseline/follow-up) are presented as follows.

Water consumption. The participants were asked how many vessels of water from which sources and in total they collected for drinking on a typical day during the week preceding the survey. Since all respondents had either collected all water from safe sources or all water from contaminated sources during that week, the final outcome was use (= 1) or non-use (= 0) of arsenic-safe water for drinking.

Affective attitude. This construct was measured with six items. The participants were asked, for example, whether they liked collecting water from the safe well, whether they felt ashamed to collect water from there, or whether they liked the taste of the water (−1 = dislike very much to 1 = like very much; Cronbach's alpha [baseline/follow-up] = .83/.77).

Instrumental attitude. The perceived expenditures of time and effort were measured with two items. For example, "Do you think that collecting water from the mitigation option is time-consuming?" (0 = not at all time-consuming to 1 = very time-consuming; Cronbach's alpha [baseline/follow up] = .89/.99). The scale was inverted, so low values reflect low attitudes (i.e., high effort/time) and high values reflect favorable attitudes (i.e., low effort/time).

Risk perception. Vulnerability and severity were each assessed with three items, which were then averaged separately. Subsequently, the risk perception scale was computed by multiplying the vulnerability scores and severity scores for each participant (Rogers, 1975). To assess vulnerability, the participants were asked, for example, how high or low the chances are that they would develop arsenicosis if they drank water from the arsenic-contaminated tubewell (−1 = very low to 1 = very high;

Cronbach's alpha [baseline/follow-up] = .76/.98). Severity was measured by asking, for example, "Imagine that you contract arsenicosis; how severe would the impact on your economic situation be?" (0 = not at all severe to 1 = very severe; Cronbach's alpha [baseline/follow-up] = .94/.89).

Injunctive norm. This was assessed with three items. The participants were asked, for example, "Overall, how much would people who are important to you approve or disapprove that (or if) you collect water from the arsenic-safe water option?" (−1 = they [would] disapprove very much to 1 = they [would] approve very much; Cronbach's alpha [baseline/follow-up] = .90/.91).

Descriptive norm. Two items measured this, by asking the participants to state the number of people outside their families/of their village who collect water from the safe water option (0 = almost nobody to 1 = almost everybody; Cronbach's alpha [baseline/follow-up] = .80/.61).

Perceived behavioral control. This was assessed with three items. The participants were asked, for example, how difficult or easy it is to find time to collect water from the arsenic-safe well (−1 = very difficult to 1 = very easy; Cronbach's alpha [baseline/follow-up] = .90/.90).

Commitment strength. Three items assessed this. The participants were asked how important it was for them to collect water from the safe option, how committed they felt to collect water from the safe well, and how annoyed they felt if they forgot to collect water from there (0 = not at all to 1 = very important/committed/annoyed; Cronbach's alpha [baseline/follow-up] = .75/.87).

Changes in psychological constructs and well-switching.

To operationalize change, the baseline values were subtracted from the follow-up values for each individual and psychological construct. Note that change scores only inform about the extent and the direction of change, not about a construct's absolute value. Well-switching is reflected by the use of an arsenic-safe well at follow-up, because all respondents were non-users of arsenic-safe wells at baseline (0 = non-user, i.e., no change, 1 = user, i.e., changed behavior).

Procedures

The baseline and follow-up surveys were conducted in December 2010 and April 2011, respectively. Interventions were delivered one month before the follow-up, in March 2011.

Data collection. Ten professional Bangladeshi interviewers were extensively trained in a 5-day workshop to conduct structured face-to-face interviews of approximately one hour in duration. The training ensured that each interviewer attained the same easily understandable vocabulary tailored to the rural participants. A quality-control team assisted the interviewers and certified the completeness of the filled-in questionnaires.

At baseline, households were randomly selected by the random-route method (Hoffmeyer-Zlotnik, 2003). The interviewers first asked to speak to the person responsible for drinking water collection in the household. Then they assessed if the household met the inclusion criteria. If yes, fully informed consent was obtained prior to conducting the interview. At follow-up, special care was taken to conduct the interview with the same household member who had been interviewed at baseline. If this person was not available, the household was re-visited once.

Interventions.

All interventions were delivered by health promoters recommended and supervised by the local non-government organization, VERC. The five female promoters (18–25 years old) lived in the vicinity of the study areas and were trained by the first author and a local collaborator regarding arsenic, arsenicosis, and arsenic-safe water options, and on how to provide the interventions correctly. At each visit, the promoters first obtained fully informed consent and then conducted the intervention session, which lasted from 20 to 60 minutes, depending on the intervention condition (each BCT required approximately 20 minutes). The participants in the public self-commitment condition were also invited to join the commitment session held in their village one week after the promoters' visit. A supervisor from VERC assisted the promoters throughout and ensured the quality of the intervention delivery. Pretesting ensured that illiterate participants would also understand all the materials. The BCTs are described as follows (intervention manuals are available at http://www.eawag.ch/forschung/siam/schwerpunkte/soziale_systeme/Beh_Change_Guideline_2012.pdf).

Information on arsenic, arsenicosis and arsenic-safe drinking water options. Using a booklet with pictograms and photographs, the promoters informed the participants about arsenic in shallow tubewell water and its adverse health effects, which they described. Then the promoters explained where arsenic-safe water was located in the participants' communities (deep tubewells) and in general (all major arsenic-safe water sources in Bangladesh).

Reminders. A set of two reminders—a poster and a tag—was developed. The poster was designed to remind the participants just before their drinking water supply was finished to collect their water from the safe option. It depicted an almost empty kalosh (local vessel for water collection, pl. kolshi) and a woman going to collect water from a green-marked (arsenic-safe) tubewell instead of a red-marked (arsenic-contaminated) one, which was crossed out. The tag was developed to remind the participants not to collect drinking water from the red-marked tubewell. It contained pictograms showing the purposes for which the water should not be used: drinking directly, boiling and then drinking, or cooking. Furthermore, the tag displayed the purposes for which the water could be used: bathing or washing dishes. The promoters first explained the contents of the poster and then installed it where the participants kept their kolshi. Next, the promoters explained the contents of the tag and installed it at the arsenic-contaminated tubewells that the participants reported using.

Implementation intentions. Since Bangladesh’s rural residents are not used to living by the clock, pictograms were used that displayed typical tasks during the day for the “when” part of the plans (e.g., sunrise, breakfast, bathing, etc.). First, the promoters asked the participants how many times a day they would have to collect water at the arsenic-safe deep tubewell; then they asked the participants to specify a situation before or after which it would suit them best to collect water (e.g., before preparing lunch). Next, the participants named a specific deep tubewell from where they committed to collect their drinking water. Subsequently, they specified how many kolshi they would collect each time they went and for which purpose (drinking, cooking, or both). Finally, the participants were asked to repeat the plan out loud after the promoter, to sign the implementation intention form by thumbprint, and to keep it somewhere safe.

Public self-commitment. These were part-informational and part-commitment sessions. First, using posters, a team of two promoters and the supervisor again explained the same information about arsenic, arsenicosis, and arsenic-safe drinking water to the participants. Then they asked the participants to commit to drinking only arsenic-safe water from now on. The participants who committed were asked to read their implementation intentions to the group. At the end of the two-hour session, tea and biscuits were offered to the participants.

Data analysis.

All calculations were computed using IBM SPSS 20.0. Hierarchical logistic regressions were performed to address whether changes in the TPB factors were predictive of behavior change, and whether changes in commitment strength, in addition, would increase the likelihood of switching to arsenic-safe wells. Multicollinearity was acceptable (all variance inflation factors < 2).

Mediation analysis was used to determine the changes in which psychological factors mediated the behavior change effects of the interventions. Procedures proposed by Preacher and Hayes (2008) were followed using the SPSS macro “PROCESS” (Hayes, 2012). For each intervention group, in comparison with the information-only group, simple mediation models were estimated. Thereafter, to determine the relative importance of the significant mediators, multiple mediation models were calculated. Bootstrapping with 1,000 resamples was applied to estimate the confidence intervals of indirect effects.

Results

Table 1 displays the descriptive statistics for water consumption and all psychological variables for all intervention groups over time. Overall, 84 households (37%) had switched to an arsenic-safe well at follow-up. Regarding psychological factors, at baseline, the participants felt quite positively towards collecting and drinking arsenic-safe water, on average, but found it time-consuming and effortful. The ratings for the injunctive norm were favorable. However, the descriptive norm was low: the households perceived only a few of their extended family or neighbors collecting arsenic-safe water. The PBC ratings indicated that the participants, on average, found it rather difficult to collect safe water. However, while participants did perceive some risk of contracting arsenicosis, they were not very committed to collecting arsenic-safe water. Overall, changes in psychological constructs from baseline to follow-up were small. Large standard deviations, however, indicated that some participants’ cognitions became more favorable toward using arsenic-safe wells, whereas others’ cognitions became more antagonistic.

Table 9. *Descriptive statistics at baseline, follow up and changes over time by intervention condition*

Time x Condition	Use of safe wells[2]	Affective attitude[3]	Instrumental attitude[3]	Injunctive norm[3]	Descriptive norm[3]	PBC[3]	Risk perception[3]	Commit-ment[3]
				Baseline				
Inf	0 (0%)	0.48 (0.31)	0.10 (0.12)	0.65 (0.27)	0.33 (0.24)	-0.77 (0.22)	0.26 (0.37)	0.34 (0.23)
Rem+inf	0 (0%)	0.45 (0.24)	0.27 (0.27)	0.68 (0.39)	0.23 (0.19)	-0.44 (0.50)	0.12 (0.34)	0.34 (0.20)
Imp+rem+inf	0 (0%)	0.56 (0.28)	0.30 (0.21)	0.51 (0.36)	0.31 (0.17)	-0.53 (0.40)	0.36 (0.34)	0.39 (0.23)
Pub+imp+rem+inf	0 (0%)	0.45 (0.30)	0.29 (0.25)	0.46 (0.42)	0.37 (0.25)	-0.42 (0.51)	0.23 (0.42)	0.32 (0.21)
				Follow up				
Inf	4 (12%)	0.54 (0.35)	0.17 (0.18)	0.72 (0.12)	0.32 (0.14)	-0.59 (0.41)	0.40 (0.48)	0.28 (0.25)
Rem+inf	23 (29%)	0.44 (0.34)	0.33 (0.31)	0.71 (0.16)	0.43 (0.16)	-0.41 (0.55)	0.26 (0.64)	0.33 (0.25)
Imp+rem+inf	29 (41%)	0.61 (0.29)	0.31 (0.26)	0.74 (0.20)	0.46 (0.16)	-0.41 (0.47)	0.46 (0.56)	0.49 (0.29)
Pub+imp+rem+inf	28 (65%)	0.49 (0.30)	0.42 (0.28)	0.76 (0.17)	0.46 (0.13)	-0.24 (0.54)	0.19 (0.69)	0.60 (0.29)
				Change[1]				
Inf	4 (12%)	0.06 (0.39)	0.07 (0.22)	0.07 (0.29)	0.00 (0.28)	0.17 (0.40)	0.14 (0.60)	-0.07 (0.26)
Rem+inf	23 (29%)	0.00 (0.44)	0.07 (0.41)	0.03 (0.42)	0.20 (0.23)	0.03 (0.74)	0.14 (0.63)	-0.01 (0.35)
Imp+rem+inf	29 (41%)	0.05 (0.39)	0.01 (0.31)	0.22 (0.37)	0.15 (0.21)	0.12 (0.57)	0.10 (0.64)	0.10 (0.37)
Pub+imp+rem+inf	28 (65%)	0.04 (0.44)	0.13 (0.40)	0.29 (0.46)	0.09 (0.26)	0.17 (0.75)	-0.03 (0.81)	0.27 (0.34)

Note. Inf = information, rem = reminders, imp = implementation intentions, pub = public commitment. PBC = perceived behavioral control. Scales ranged from 0 to 1 (unipolar items) or from -1 to 1 (bipolar items).

[1]Individual baseline values were subtracted from follow up values, [2] *f* (%), [3] *M* (*SD*).

Predicting well-switching with psychological changes

Hierarchical logistic regressions to predict well-switching by the time of the follow-up confirmed all hypotheses (H1a–c; see p. 112). In the first step, changes in the TPB variables significantly increased the −2 log likelihood of the constant-only model to predict well-switching (H1a; χ^2[6, 226] = 68.81, $p < .001$). In the second step, changes in commitment strength, as hypothesized, significantly contributed to predicting well-switching (H1c; χ^2[7, 226] = 175.94, $p < .001$). Increases in commitment strength were strongly predictive of well-switching at follow-up. Further significant factors in the last step were changes in risk perception, which were unexpectedly negatively associated with the use of arsenic-safe wells at follow-up. Changes in affective attitude were negatively related to well-switching after commitment strength was added.

Table 10. *Hierarchical logistic regressions to predict well-switching with changes in psychological factors*

	Model 1		Model 2		
Changes in…	*B*	*OR*	*B*	*OR*	95% CI
Affective attitude	1.28**	3.60	-1.90*	0.15	[0.04, 0.63]
Instrumental attitude	1.78**	5.94	1.78	5.93	[0.85, 41.26]
Risk perception	-1.29***	0.27	-1.53***	0.22	[0.09, 0.50]
Injunctive norm	0.70	2.02	0.49	1.64	[0.60, 4.50]
Descriptive norm	1.71**	5.52	0.04	0.96	[0.15, 6.26]
PBC	0.17	1.19	0.86	2.37	[0.86, 6.50]
Commitment			8.40***	4426.34	[383.95, 51028.46]
Nagelkerke R^2	0.36		0.74		
% correct	76.1%		89.4%		

Note. N = 226. At baseline all participants were non-users of arsenic-safe wells. Well-switching by the time of follow up was coded “1” (0 = did not switch to safe well). Scales ranged from 0 to 1 (unipolar items) or from -1 to 1 (bipolar items). PBC = perceived behavioral control, *B* = unstandardized regression coefficient, *OR* = odds ratio, CI = confidence interval. * $p < .05$; ** $p < .01$; *** $p < .001$.

Intervention effects on well-switching

As expected, considerable behavior change differences were observed between the intervention conditions (see Table 9). While in the information-only comparison condition, 12% of the participants had switched, 65% had switched in the condition where all the theory-based BCTs were added (pub+imp+rem+inf). The results of the logistic regressions of the behavior change effects of the interventions revealed that the theory-based intervention condition imp+rem+inf significantly increased the behavior change effects of the information comparison condition (41% switched; $B = 1.67$, $SE = 0.59$, $p = .004$). The effect was even stronger in the pub+imp+rem+inf condition (65%; $B = 2.64$, $SE = 0.62$, $p < .000$). The addition of reminders (rem+inf) also increased the behavior change effects of the intervention, but this effect was only marginally significant (29% switched; $B = 1.13$, $SE = 0.59$, $p = .055$).

Mediators of the behavior change effects of the theory-based BCTs

Table 11 shows the results of simple mediation models to investigate the mechanisms of behavior change promoted by the theory-based BCTs.

Supporting hypothesis H3a, the increased behavior change effects of the theory-based BCTs targeting commitment strength were significantly mediated by changes in commitment strength for the imp+rem+inf condition. The indirect effect was even stronger for the pub+imp+rem+inf condition. However, the theory-based intervention condition with reminders and information alone (rem+inf) only had a small and insignificant effect on changes in commitment strength. The indirect effect was not significant. Unexpectedly, rem+inf had a significant effect on changes in descriptive norms, although the indirect effect was insignificant. Unexpected additional indirect effects were found for the imp+rem+inf condition: changes in descriptive and injunctive norms mediated the increased behavior change effects. The intervention with all three theory-based BCTs (pub+imp+rem+inf) had a medium effect on increasing injunctive norms, and a small, insignificant effect on increasing descriptive norms. However, hypotheses H3b and H3c were not supported, as the indirect effects were small and not significant.

A multivariate mediation model was only computed for the imp+rem+inf condition; the other intervention conditions did not display multiple mediators in the simple analyses. In this model, changes in injunctive and descriptive norms did not mediate the behavior change effects of the intervention. Change in commitment strength was the only significant indirect effect.

Table 11. *Simple mediation models to test the mediators of the theory-based BCTs' increased effects on well-switching*

	Intervention			Well-switching[1]			Indirect effects (90% CI)		
Changes in…	*B*	*SE*	*p*	*B*	*SE*	*p*	*LL*	*B*	*UL*
Affective attitude									
Rem+Inf	-0.07	0.09	0.430	1.85	0.61	0.003	-0.50	-0.13	0.11
Imp+rem+inf	-0.00	0.08	0.972	0.30	0.57	0.596	-0.11	-0.00	0.07
Pub+imp+rem+inf	-0.02	0.10	0.849	1.52	0.70	0.029	-0.34	-0.03	0.24
Instrumental attitude									
Rem+Inf	-0.00	0.08	0.964	3.63	0.89	< .001	-0.40	-0.01	0.37
Imp+rem+inf	-0.06	0.06	0.156	1.79	0.80	0.026	-0.37	-0.11	0.02
Pub+imp+rem+inf	0.06	0.08	0.472	0.88	0.79	0.264	-0.04	0.05	0.35
Risk perception									
Rem+Inf	-0.00	0.13	0.988	-1.66	0.44	< .001	-0.33	-0.00	0.42
Imp+rem+inf	-0.04	0.13	0.767	-0.74	0.37	0.044	-0.10	0.03	0.31
Pub+imp+rem+inf	-0.18	0.17	0.283	-1.04	0.44	0.018	-0.06	0.19	0.71
Injunctive norm									
Rem+Inf	-0.04	0.08	0.630	0.01	0.56	0.979	-0.09	-0.00	0.08
Imp+rem+inf	0.16	0.07	0.033	1.61	0.66	0.015	**0.06**	**0.20**	**0.59**
Pub+imp+rem+inf	0.23	0.09	0.016	0.32	0.66	0.627	-0.19	0.07	0.43
Descriptive norm									
Rem+Inf	0.21	0.05	< .001	1.07	0.95	0.256	-0.12	0.22	0.67
Imp+rem+inf	0.16	0.05	0.002	2.06	1.05	0.050	**0.05**	**0.32**	**0.82**
Pub+imp+rem+inf	0.09	0.06	0.137	0.39	1.03	0.704	-0.13	0.04	0.30
Perc. behavioral control									
Rem+Inf	-0.15	0.14	0.280	1.71	0.44	< .001	-0.65	-0.25	0.06
Imp+rem+inf	-0.06	0.11	0.610	0.72	0.42	0.065	-0.29	-0.04	0.05
Pub+imp+rem+inf	-0.00	0.14	0.997	1.18	0.48	0.014	-0.30	-0.00	0.32
Commitment strength									
Rem+Inf	0.06	0.07	0.399	7.35	1.56	< .001	-0.29	0.42	1.29
Imp+rem+inf	0.17	0.07	0.018	6.40	1.28	< .001	**0.37**	**1.11**	**2.23**
Pub+imp+rem+inf	0.35	0.07	< .001	4.49	1.22	< .001	**0.76**	**1.57**	**2.94**

Note. Inf = information, rem = reminders, imp = implementation intentions, pub = public commitment. Intervention was coded "1", information-only control was coded "0". Indirect effects were calculated by bootstrapping (bold: significant effects). *B* = unstandardized regression coefficients from linear regressions (column "Intervention") or logistic regressions (column "Well-switching"). *SE* = standard error, CI = confidence interval, *LL* = lower limit, *UL* = upper limit.

[1] Effect of potential mediator on well-switching when the intervention effect was controlled for.

Discussion

This study investigated the importance of commitment strength in the behavior change process. To investigate this, theory-based BCTs targeted at increasing commitment strength were added to an informational intervention to change safe water consumption. As expected, the TPB variables successfully predicted well-switching. This is in line with previous research on safe water consumption (Altherr et al., 2008; Kraemer & Mosler, 2012) and other health behaviors (Fishbein & Ajzen, 2010). Changes in commitment strength substantially increased the power of the TPB and emerged as the strongest predictor of well-switching. Theory-based BCTs targeted at increasing commitment strength (public self-commitment, implementation intentions, and reminders), when added to a promoter-delivered informational intervention, yielded superior behavior change effects in comparison to information alone, particularly when public self-commitment, implementation intentions, and reminders were combined. While the added theory-based BCTs also promoted changes in social norms, changes in commitment strength emerged as the sole mediator of the intervention’s effect on behavior change. This underlines the importance of commitment in the behavior change process.

An interesting finding is the negative relation of risk perception and well-switching. This may indicate that people with a decreased perception of the personal risk of developing arsenicosis were more likely to switch to arsenic-safe wells at follow-up. However, this may also indicate that people who switched to safe wells perceived lower personal risks than when they were drinking contaminated water. This counter-theoretical finding was also reported by Norman and Conner (2005). Experimental research manipulating risk perception is necessary to provide conclusive evidence of the relationship between risk perception and behavior change.

Regarding the effects on well-switching, the augmentation of information-based interventions with theory-based BCTs proved very useful. Even simple reminders increased the behavior change effects of information by almost 20%. The combined intervention increased well-switching rates by more than 50%. These results are in line with the finding that raising awareness alone has limited effects on increasing safe water consumption (Hoque et al., 2004; Opar et al., 2007), and they extend the research on the effectiveness of implementation intentions to another health behavior. The effects are particularly encouraging for further application in developing countries, due to their simplicity and low cost—a maximum of 2 USD per household in the overall intervention condition. However, it is vital to ascertain the sustainability of the behavior change. What must also be considered is the large dropout rate in the public self-commitment condition. While the promoters’ household visits reached most of the participants, almost two-thirds of the participants did not attend the public self-commitment sessions. This must be taken into account when selecting this BCT for interventions. Furthermore, a possible dropout bias for the group with public self-commitment should be considered when interpreting the added behavior change effect of this BCT.

As expected, the theory-based BCTs primarily induced increased behavior change by increasing commitment strength. Neither affective or instrumental attitudes, nor risk perception or perceived behavioral control were modified by the BCTs. Most variations of the intervention increased the subjective and descriptive norms. Unexpectedly, however, the changes in these factors were only found in the simple mediation analyses for the group with implementation intentions, reminders, and information. In the multivariate model, commitment strength was the sole significant mediator of the intervention, indicating that implementation intentions, at least in combination with reminders and information, elicited their effects through changing commitment strength. Contrary to the assumption, however, reminders were not sufficient to elicit commitment change. As outlined in the introduction, reminders are only assumed to enhance commitment when individuals interpret them as requests to commit (Tobias, 2009). In this study, the reminders were provided by the health promoters and not by the participants themselves. Therefore, it is likely that most participants did not interpret the reminders as a request. Future studies should compare the commitment changes of individuals who install reminders themselves with individuals whose reminders are installed by others.

The shortcomings of the present study are the small and unequal sample sizes. The small number of participants in the information-only comparison arm in particular may have decreased the power to detect significant results. As many of the reported effects were small, future studies should recruit more participants. Furthermore, the interval between the baseline assessment and the implementation of the intervention should be reduced, as this may be a possible source of the small effects of the interventions on the change in psychological variables.

This study uncovered how public self-commitment and implementation intentions change behavior when combined with reminders and information. However, combining the different BCTs made it impossible to completely disentangle the effects of the BCTs. For example, the results do not allow the interpretation that commitment is elicited by implementation intentions alone or whether it is a requirement that they are implemented in combination with reminders and information. Future studies should also consider additional potentially important mediators of the BCTs. For example, it would be interesting to investigate if the construct “action planning,” the extent of how detailed participants perceive the formed plans (Schwarzer, 2008), mediates the behavior change effects of the BCTs. More importantly, it would be interesting to investigate the relation between planning and commitment strength. A research question could be whether more detailed plans follow stronger commitment or whether planning leads to increased commitment to carry out a change in behavior.

In conclusion, commitment strength emerged as an important factor for changing safe water consumption and is likely relevant for other health behaviors as well. Therefore, the researchers hope that this study will spark further research on the role of commitment in health behavior change.

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Chapter VI

General discussion

1. Summary

This thesis aimed at developing and testing theory-based interventions to promote safe water consumption. This was investigated at the example of promoting arsenic-safe water consumption in Bangladesh. First, a theoretical framework was proposed by an integration of major theories of health behavior. The behavioral determinants from the framework were then assessed in three empirical studies that were conducted in rural Bangladesh employing structured face-to-face interviews. The results revealed the acceptance and use of several arsenic-safe water options (Chapter II), and the relative importance of the determinants in explaining and predicting safe water consumption (Chapters III-V). Moreover, interventions were developed based on the assessment of the determinants from the theoretical framework (Chapter IV). In cluster-randomized controlled trials, these were found to effectively promote switching to arsenic-safe wells over and above a standard informational intervention (Chapters IV and V). Finally, the theory-based BCTs were shown to change behavior primarily by increasing commitment strength (Chapter V).

The results of the empirical studies were discussed in detail in the respective chapters. This general discussion therefore focuses on the overall implications of this research. Nevertheless, a brief overview of the most important results is given first. Table 12 presents this thesis' main results with regards to the aims and research questions, and summarizes the major conclusions that were drawn. The chapter numbers indicate where detailed information on the investigations can be found.

Next, the implications for behavior change theory and health-behavior promotion are discussed. This is followed by recommendations to accelerate arsenic mitigation in Bangladesh. Thereafter, strengths and limitations of this research are outlined, and general conclusions are drawn. Also, future directions in research and practice are proposed. These can be found throughout this chapter rather than in a separate section.

Table 12. *Overview of this thesis' main findings*

Aim	Research questions	Chapter	Results	Conclusions
Gain knowledge about the target behavior and population	(1) To what extent are available safe water options actually used by people living in contaminated areas?	II	Overall, two thirds of respondents used available safe water options. But there was great variability in the number of users between the eight arsenic-safe water options (range: 37% - 93% use).	The number of people who are at risk of drinking arsenic-contaminated water has likely been underestimated. Piped water supply should be promoted if technically and financially feasible. If not, deep tubewells should be prioritized.
	(2) Which safe water options are more accepted than others regarding psychological factors, both for users and non-users?		Piped water supply and deep tubewells were the most accepted, dug wells and well-sharing were the least accepted safe water options.	The use of each safe water option can be improved by employing the BCTs suggested for targeting the low acceptance factors.
Identify determinants of arsenic-safe water consumption	(3) Which factors are related to the habitual use of arsenic-safe water options?	III	Self-efficacy and descriptive norms were most strongly related to habitual arsenic-safe water consumption. Further important were instrumental attitude and injunctive norms. Vulnerability was unexpectedly negatively related to the outcome. The model fit was very good.	Social-cognitive factors can explain sustainable safe water consumption well. Norms and self-efficacy are strongly related to habitual safe water consumption.
	(4) How well does this general model predict the use of specific water options?		The model proved highly generalizable to all seven arsenic-safe water options investigated.	The model can be applied to enhance the habitual use of any arsenic-safe water option, even those that were not considered in this study.
	(5) Which behavioral determinants can explain the use of neighboring arsenic-safe wells?	IV	Descriptive norms, commitment strength, and recovery self-efficacy were most strongly related to use of neighboring arsenic-safe wells. Further explanatory factors were maintenance self-efficacy, attitudes, injunctive norms, and vulnerability (negatively).	Commitment strength emerged as an important behavioral determinant. Also, the importance of the descriptive norm and self-efficacy to explain safe water consumption was further corroborated. The negative association of vulnerability with safe water consumption was replicated.
	(6) Can factors from the TPB and commitment strength predict switching to arsenic-safe deep tubewells?	V	Changes in TPB variables and particularly commitment strength were highly predictive of switching to arsenic-safe deep tubewells at follow up.	Commitment strength is an important determinant of safe water consumption.

Table 12. *Overview of this thesis' main findings (continued)*

Aim	Research questions	Chapter	Results	Conclusions
Develop and test theory-based interventions	(7) Which behavioral determinants have the greatest improvement potentials to promote switching to arsenic-safe wells?	IV	The descriptive norm, commitment strength, self-efficacy, and vulnerability (negatively related to well-switching) were identified as the determinants with highest improvement potentials (i.e. strong associations with safe water consumption and high changeability).	BCTs were selected to increase commitment strength and descriptive norms: reminders, implementation intentions, and public self-commitment
	(8) Do theory-based BCTs increase behavior change effects of informational interventions?		Theory-based interventions augmented the behavior change impacts of an informational intervention by up to 48%. Implementation intentions with reminders and information had largest effects (66% switched to safe wells). Unexpectedly, the public self-commitment addition yielded similar effects as information alone.	Theory-based BCTs can significantly enhance informational interventions to promote well-switching. The effects in the public self-commitment group may be explained by group processes. This requires further study.
		V	Theory-based interventions augmented the behavior change impacts of an informational intervention by >50%. Combining public self-commitment, implementation intentions, reminders and information had largest effects (65% switched).	Theory-based BCTs can significantly enhance informational interventions to promote deep tubewell use.
Investigate the mecha-nisms of theory-based interventions	(9) Do the theory-based additions to an informational intervention increase switching to arsenic-safe wells by changing commitment strength?	V	Changes in commitment strength was the most important mediator of the additional behavior change effects of the theory-based interventions that combined information with reminders and implementation intentions, or with an additional public self-commitment compared to information alone.	Public self-commitment and implementation intentions, when combined with reminders and information, can increase commitment strength, which in turn promotes behavior change.

2. Implications for health behavior theory

In this section, the results regarding the determinants of health behaviors are discussed. First, the different results from the four empirical studies of this thesis will be compiled and discussed to offer an overview of the behavioral determinants of safe water consumption. Then, the proposed causal framework will be critically appraised.

2.1. Determinants of safe water consumption

All empirical chapters in this thesis investigated the behavioral determinants of arsenic-safe water consumption. The studies employed different cross-sectional, longitudinal, and field-experimental designs, and investigated the use of different arsenic-safe water options. Common results will therefore indicate some generalizability of the determinants for safe water consumption.

Throughout, the results from the cross-sectional investigations (Chapters II-IV) and the longitudinal investigation (Chapter V) strongly demonstrated the ability of social-cognitive variables to explain and predict safe water consumption. Regarding the behavioral determinants, there is strong evidence for the importance of commitment, the descriptive norm, and self-efficacy to explain and predict safe water consumption. This is in line with previous research on safe water consumption (Huber & Mosler, 2012; Huber et al., 2012; Kraemer & Mosler, 2012; Mosler et al., 2010; Tamas & Mosler, 2011; Tobias & Berg, 2011). Further influences are vulnerability, the instrumental attitude, instrumental and affective attitudes, and the injunctive norm. The results thus indicate that more committed persons, who perceive safe water collection as more typical, have higher confidence in their abilities to collect safe water, who feel less likely to develop arsenicosis, find safe water collection less time-consuming and effortful and more enjoyable, and who perceive more approval from others to collect arsenic-safe water are more likely to use arsenic-safe water options. Some of the most interesting results will be discussed in the following.

The most important factors: Commitment, the descriptive norm, self-efficacy

All three determinants were of similar importance in the cross-sectional investigation of Chapter IV. However, confirming its prominent role in the proposed theoretical framework, commitment strength emerged as by far the strongest predictor of switching to arsenic-safe wells in the longitudinal investigation (Chapter V). The impact of the descriptive norm on well-switching, on the other hand, was drastically reduced by the inclusion of commitment strength. In fact, most of the outcome expectancies' effects on behavior were reduced by including commitment strength to predict behavior change. Similarly, in Chapter IV, the influence of outcome expectancies (except for the descriptive norm) compared to commitment and self-efficacy on the use of neighboring safe wells were small. These results do not support the assumption of some behavioral models that the beliefs about behavioral consequences have direct effects on behavior (e.g. SCT, Bandura, 2001). Rather, more proximal determinants seem to mediate their influence.

In line with an earlier study on arsenic-safe water consumption (Mosler et al., 2010), self-efficacy was confirmed as an important determinant in the general model (Chapter III). This indicates that peoples' confidence in their abilities to collect arsenic-safe water is crucial for mitigation behavior. In contrast to these findings, however, the PBC measures (Chapters IV & V) did not predict switching to arsenic-safe wells. This supports research that distinguishes between perceived difficulty (i.e. PBC) and self-efficacy (Trafimow, Sheeran, Conner, & Findlay, 2002). The latter may be more important than perceived difficulty to explain safe water behaviors, but this should be further investigated.

The roles of risk perception and knowledge

A common belief of health practitioners is that people need to be made aware of their personal likelihoods to suffer severe health consequences, where after they will gladly refrain from the unhealthy behavior and start collecting safe water, dieting, exercising etc. In brief, in line with previous research on water consumption (e.g. Kraemer & Mosler, 2010; Mosler et al., 2010; Tobias & Berg, 2011) and other health behaviors (Luszczynska & Schwarzer, 2003), this thesis yielded very little support for this notion.

In Chapter II knowledge significantly differentiated between users and non-users of safe water options. However, the differences were very small and need to be interpreted in relation to the study's large sample size. In Chapter IV, the bivariate relation of knowledge and the use of neighboring arsenic-safe wells was very small and insignificant. Overall, this supports the conceptualization of knowledge as a more distant behavioral factor, which is suggested for example in the TTI (Flay et al., 2009).

Some behavior change was found in the informational intervention group, which may be regarded as an indicator of changed knowledge or risk perception. Indeed, risk perception in the information group had increased from baseline to follow up. However, this does not allow the conclusion that the behavior change was caused by changes in risk perception. There may be alternative explanations, such as normative effects due to the promoter visit. In our study, for example, perceived behavioral control also increased from baseline to follow up. Future studies would benefit from having a further control group that does not receive arsenic-related risk information. Then, mediation models can be computed that may shed light on the mechanisms of informational interventions.

Perceived severity of arsenicosis (i.e. impacts on life in general, social life, and economic situation), was consistently rated high in all of the studies, and was mostly unrelated to safe water consumption, at least when other factors were also considered. This is consistent with previous studies on health behaviors (Harrison, Mullen, & Green, 1992; Janz & Becker, 1984). Perhaps, severity will exert more influence on behaviors where more differences in severity are found. But for most behaviors it may be sufficient to focus on vulnerability and omit severity from risk perception measures, as it is implemented for example in the HAPA (Schwarzer, 2008).

A consistent result of the present research is the inverse relation of perceived vulnerability and safe water consumption. This inverse relation has also been noted for other health behaviors (see Norman & Conner, 2005). As eluded before, this may either imply that people who feel more vulnerable consequently consume less arsenic-safe water, or, that people who drink arsenic-safe water consequently feel less vulnerable. Even though Chapter V employed a longitudinal design, the causal pathway of this relationship cannot be ascertained. However, open-ended answers to the question why people felt more or less likely to develop arsenicosis provided some insight (see Chapter II). These corroborated the notion that people who drink arsenic-safe water consequently feel less likely to develop arsenicosis. Interestingly, of the respondents who drank arsenic-contaminated water, some felt vulnerable because they drank this water, whereas others did not. It may be worthwhile further exploring the vulnerability-behavior relationship with experimental designs, e.g. with tailored interventions for different subgroups.

Further influences: Instrumental attitude and the injunctive norm

When asked directly, participants consistently mentioned distance to safe water options as the major disadvantage or difficulty to collect arsenic-safe water. Indeed, consistent with previous research (e.g. van Geen et al., 2002) many participants walked great distances to collect water several times a day. This aspect was therefore integrated into the measure of instrumental attitude; it reflected how time-consuming or effortful participants perceived collecting or preparing safe water. In line with people’s direct answers, the results on instrumental attitude in this research provide consistent evidence that perceived expenditures of time and effort are related to safe water consumption. However, when other determinants (e.g. commitment) were considered, the effect of the instrumental attitude subsided or was comparatively small. One explanation for this may be that commitment compensates for the hardship of collecting safe water. According to theory, commitment indicates that a person is willing to invest effort into goal enactment (Nenkov & Gollwitzer, 2012). Highly committed persons may therefore be willing to walk further to collect safe water then less committed persons. It would be interesting and practically important to ascertain, how far such a commitment effect can be extended. There may be a threshold, for example, where distances to safe wells are too far, and increased commitment will not lead to overcoming this barrier. Knowing such a threshold would be of high practical relevance, as this would indicate when behavior change interventions need to be supported by installing further safe water options in order to be effective.

In comparison to the descriptive norm, the injunctive norm exerted minor influences on safe water consumption, at least in the cross-sectional investigations. The results from the cluster-randomized trial, on the other hand, demonstrated that increased perceived approval by others mediated the increased behavior change effects of implementation intentions and reminders compared to information. In conclusion, evidence from this research indicates some influence of the injunctive norm on safe water consumption, but did not corroborate the extent of influence found in an earlier cross-sectional study (Mosler et al., 2010).

Cognitions about the alternative behavior

These were only included to some extent in the general model investigated in Chapter III. Descriptive norms regarding the contaminated well did not exert influence on habitual use of arsenic-safe wells when cognitions about the safe water options were considered. However, results indicated that participants with higher taste preferences or who had higher preferences for the taste of the water from the contaminated well (i.e. affective attitude), were less habitual to use arsenic-safe wells. Interestingly, the affective attitude regarding the safe option did not prove influential. This confirms results of Mosler et al. (2010) who also found that the taste preferences for the water from the contaminated option, and not the safe water option were related to the use of arsenic-safe wells. However, the size of this effect was small. Therefore, overall, considering the alternative behavior did not yield particularly novel insights in this investigation. It is certainly interesting to explore the cognitions about the alternative behaviors when planning interventions. This must, however, also be weighed against the considerable added load for participants to answer these additional questions. After the exploration (i.e. a pilot survey), it is therefore recommendable to only include items on constructs regarding the alternative behavior that proved influential over and above the influence of target behavior-related cognitions to explain the behavioral outcome.

Planning

In the framework model of behavior change presented in Chapter I, planning is one of the proximal predictors of behavior. However, in this research, planning did not emerge as influential, neither in Chapter III, nor in Chapter IV, and it was subsequently not considered in Chapter V. There are several possible explanations for this. First, only coping planning was considered in the analyses. Although action planning was assessed, it was not possible to include this variable in the analyses. Following Schwarzer’s (2008) example for defining action planning, action planning was operationalized to capture plans, when, where, and how to initiate action. Consequently, individuals who were using arsenic-safe water options at the time of the survey did not answer this question. In hindsight, while this operationalization may be sensible for investigating stage models, was not suitable for the present study, as non-intenders, intenders, and actors were investigated simultaneously. From a continuum-model perspective, action planning or implementation intentions can occur at any given point on the behavioral continuum. Therefore, future studies should assess action planning for all participants, regardless of their current position on the continuum.

A further possible reason why coping planning was not influential in explaining safe water consumption may be that the concept of making detailed plans is not appropriate for the context of rural people’s safe water collection behaviors. While there may certainly be barriers to collecting water from safe wells (e.g. broken well), they usually require simple alternative actions (e.g. locating a further safe well and going there). Furthermore, it is likely that rural Bangladeshi people generally do not plan their actions in such detail as is entailed by the planning concepts. In future studies, assessing the presence of action alternatives may be a better option. For example, to ask people what they would do if their safe well were broken, and then code the open answers according to their detail.

2.2. Appraisal of the causal framework

A theoretical framework was compiled to contain the most important theory-derived determinants of health behaviors. The aim of this compilation was to gain a comprehensive overview of possibly influential determinants in safe water consumption and their relationships, in order to develop maximally effective behavior change interventions. Although a theory test was not the primary goal, this research allows certain appraisal of some of the framework’s propositions. One is the prominent role of commitment strength in the model, which was derived from the MPMH (Tobias, 2009). Another conceptualization is the continuum of habitual behavior that includes both current behavior and its habit strength. Finally, it was argued to omit behavioral intention from the model. These propositions will be briefly discussed with respect to the research findings.

The importance of commitment in behavior change

This research provides strong evidence of Tobias’ (2009) proposition of the importance of commitment in behavior change, and is in line with most recent findings on the importance of commitment in safe water consumption (Huber & Mosler, 2012). Particularly the experimental manipulation of commitment strength through intervention confirmed commitment as an important modifiable mechanism of change. This is encouraging for future research on commitment, which should aim at answering several further research questions. For example, in the proposed framework, while commitment can be influenced directly, is also anteceded by outcome expectancies, and self-efficacy. This can be thought of as the bottom-up development of commitment, i.e. the “slow” process. Some of this mediating role of commitment of effects of outcome expectancies was provided in Chapter V. But future research should investigate this further. Of particular interest would also be the relationship between commitment and planning. In the framework, a feedback function between the two was assumed. In fact, commitment and planning may also be seen as two aspects of a similar construct, as one reflects the strategic part (i.e. detailed planning), and the other reflects arousal or a tension state (i.e. commitment; cf. Tobias, 2009). Both are ultimately assumed to affect behavior by increasing accessibility (Webb & Sheeran, 2008; Tobias, 2009). Future research should shed some light into this relationship by including planning and commitment simultaneously in analyses. This could be done, for example, by employing a 2x2 design; manipulating planning (e.g. by forming implementation intentions) in one condition and manipulating commitment (e.g. by public commitment) in another. The feedback assumption would be supported if increasing commitment would lead to forming detailed plans and if forming implementation intentions would lead to increased commitment. Of interest would also be which manipulations would lead to greater behavior change.

Another issue that requires investigation is the discrimination of commitment strength to other constructs, e.g. behavioral intention, plan commitment (de Vet et al., 2011), or goal commitment (e.g. Gollwitzer, 1999). Plan commitment is the importance to adhere to a plan to enact intentions (de Vet et al., 2011). Goal commitment is "… a strong sense of determination, unwillingness to abandon or lower the original goal, willingness to invest effort, and effortful striving for goal implementation." (Nenkov & Gollwitzer, 2012, p. 108). Puzzlingly, while the conceptualizations of commitment differ, the operationalization partly overlaps (see Klein, Wesson, Hollenbeck, Wright, & DeShon, 2001 for the goal commitment scale, and de Vet et al., 2011 for the operationalization of plan commitment). Future research should investigate if these concepts are separable at all.

Habitual behavior

This study argued that behavior is a continuum from no behavior to habitual behavior. The results provide some support for this by the fact that similar factors emerged as important behavioral determinants in the empirical studies, regardless of the outcome – habitual or current behavior. However, these similarities may have also emerged if the behavioral part of the habitual behavior scale dominated the measure. In fact, due to the dichotomy of water consumption behavior in Bangladesh for a given day, the habitual behavior scale was indeed bimodal. This dichotomous nature of water consumption in Bangladesh may therefore not have been ideal to investigate the conceptualization of habitual behavior. Future studies on the habitual behavior concept should preferably investigate continuous behaviors, where medium habit strengths occur more frequently. In such studies, the predictors of habitual behavior should be formally compared with the predictors of behavior within the study. Ideally, predictors of the habit scale would correspond to predictors of behavior, which would again respond to predictors of habitual behavior. This would indicate maximum relevance for the habitual behavior concept.

Behavioral intention

Behavioral intention was excluded from the proposed theoretical framework. By being a mediator of more distal motivational variables, it was argued that it would cover the effects of those factors. Furthermore, it appeared difficult to directly intervene on intention, wherefore, in summary, intentions seemed to have little practical value for campaign planning. Lately, however, research has shown that intention formation can have unexpectedly strong impacts on habit disruption (e.g. Danner, Aarts, Papies, & de Vries, 2011). The authors were able to explain this by an inhibitory effect of goal setting on the habitual response (Danner et al., 2011). However, they also admit that this effect possibly depends on commitment, and that implementation intentions may be more effective, particularly in the presence of strong habits (Danner et al., 2011). Nevertheless, if this technique proves useful to change behavior, this may ultimately lead to a re-consideration of intention in the model. Alternatively, intention may be included into the concept of habitual behavior as a measure of action readiness of individuals who are not yet performing the behavior, as was perhaps intended by Abraham (2008).

Hereby the discussion of theoretical implications of the results concludes. Next, reflections on the implications for health promotion will be presented.

3. Theory-based health promotion

Over the course of the empirical studies presented here, all requirements for theory-based interventions were met (see Michie & Prestwich, 2010); theoretical constructs were targeted by the BCTs, the targeted constructs were measured, and mediating effects were ascertained. This is one of the first studies in the safe water domain that rigorously applied theory throughout the intervention process. Furthermore, this study is one of the few studies that successfully showed that interventions changed behavior by changing the intended behavioral determinants. The practical relevance of these results for health promotion in general and future directions will be highlighted next. The relevance of the results for arsenic mitigation in particular will be discussed thereafter.

Superior behavior change effects of theory-based interventions

Using theory at every step of the health promotion process is not merely a psychologists’ bauble. It is of great practical value. In this thesis, the superior effects of the theory-based interventions compared to commonly applied interventions were demonstrated. Such strong tests of theory-based interventions are rare (Michie & Prestwich, 2010). While there is increasing literature on the behavior change effects of theory-based interventions (e.g. Conner et al., 2011; Hagger et al., 2012; Michie, Abraham, Whittington, & McAteer, 2009; Peters, Kok, Ten Dam, Buijs, & Paulussen,, 2009), most studies have used “no-intervention” control conditions to estimate the effects. This study, in contrast, specifically tested the increased effects of theory-based interventions. As eluded, such studies require comparison groups with “standard” interventions that are compared with “standard-plus” interventions that contain the theory-based elements (Michie et al., 2009; Williams, 2010). The results of the present study corroborate the superior effects of theory-based interventions found in the few studies that employed such research designs (Albarracín et al., 2005; Luszczynska & Tryburcy, 2008). But clearly, more research in this domain is required.

Another issue concerns the durability of the observed intervention effects. This was not assessed in the present study. As described in the introduction, Studies 2 and 3 were both four-wave panel studies with two intervention periods, and a 6-months phase of inactivity between the third and the fourth panel. The preliminary results of the second intervention phase indicate that the behavior change effects of the first phase was quite stable; few participants in the theory-based interventions conditions had switched back to using contaminated wells (Inauen, Harter, & Stocker, 2012). The results on the longer-term sustainability after the phase of inactivity are underway.

Why and for whom interventions work

Besides rendering superior effects, theory-derived interventions can provide further useful information for intervention planners. In particular, important additional insights can be gained, *how* the interventions worked (Abraham, 2012). In this research, it was shown that implementation intentions, when combined with reminders, and information, increased water consumption by enhancing commitment strength. This effect was even stronger when public commitment was added to the intervention. This confirms assumptions made by the proposed theoretical framework, and of other behavior change models (Mosler, 2012; Tobias, 2009). As a next step, this effect should be replicated for switching to neighboring arsenic-safe wells with the data from Study 2. One limitation of the study was that the theory-based BCTs were not studied in isolation. The possibility that commitment strength was only enhanced due to a synergetic effect of, for example, implementation intentions, reminders, and information, cannot be ruled out. Future studies should disentangle these effects, as this would also be of practical value; to keep the intervention as cost-effective as possible, elements of the intervention (e.g. reminders) may be omitted if found to be ineffective.

A further important question is, for whom specific interventions work or do not work (Abraham, 2012). This was not addressed by the present research. From the results it is clear that the interventions, although generally successful, were ineffective for some of the participants. This is a question of moderators. One possible moderator is the distance to the safe well (cf. Opar et al., 2007). Possibly, the intervention lead to an increased commitment to collect safe water, but the commitment was not strong enough to overcome very great distances. Identifying such moderators is of great practical relevance as such findings would imply tailoring interventions to segments of the target population.

The mode of delivery

A vast area of future research is the mode of delivery of interventions, i.e. the communication channels used to apply the BCTs. This was not addressed in this thesis. Promoters were selected to deliver interventions in both studies, as previous research indicated their effectiveness in enhancing behavior change in the water and health domain, followed by opinion leaders, and weakest effects observed of a health fair (Tamas, Tobias, & Mosler, 2009). It would be interesting to investigate if the same BCTs rendered similar effects if delivered, for example, by local media instead of promoters. Such information would be highly practically relevant, as with local media more people can be reached than with personal household visits. So far, Tamas and colleagues’ study is one of the few to systematically have compared the effects of different communication channels. A prerequisite for such an analysis is that the same BCTs are applied by all communication channels, which was the case in the Tamas et al. study (persuasive arguments and reminders). Again, besides the comparison of behavior change effects, it would be of special interest if the mode of operation of the BCTs differed if delivered with different communication channels. This is a further, vast area of research, as there exist at least 40 different BCTs (Abraham, 2012), that may be tested with several communication channels.

After this discussion of overall practical implications, recommendations for arsenic mitigation will be derived in the next section.

4. Recommendations for arsenic mitigation in Bangladesh

This research has several implications how arsenic mitigation in Bangladesh may be accelerated. The focus of this thesis was on individual behavior change. Insights were gained about people’s acceptance and use of different available arsenic-safe water options, and how the use of these options can be enhanced. Whereas it was found that up to two thirds of people do not use the safe options they have access to, encouraging results from the investigated behavior change interventions were found. However, as eluded in the introduction, to mitigate a problem of this complexity, behavioral, institutional, and technical aspects must be jointly considered to achieve sizeable and long-lasting mitigation. This section therefore aims at providing recommendations for arsenic mitigation that integrate the findings from the behavior change perspective with the state of the art of technical and institutional aspects of the issue.

Implement piped water supply and deep tubewells

Piped water supply and deep tubewells emerged as the most socially accepted and used safe water options. These two options are also the most preferred of agencies involved in arsenic mitigation in Bangladesh (Khan & Yang, 2012). Moreover, both options are, considered technically sound for many areas in Bangladesh.

People are demanding piped water supply (e.g. Hoque et al., 2004; Hanchett et al., 2002), and are also willing to pay for its use (Ahmad, Goldar, & Misra, 2005). To increase people’s sustained financial contribution and thus ensure regular maintenance of the systems, it is recommendable to employ a participatory approach, as otherwise the systems may fail (e.g. Bhattacharjee, 2007). Besides high initial cost of setting up piped water supply systems, they are also technically complex. Besides allocating more funding, recruitment of specialized personnel may therefore be helpful, as this has been reported a major hindrance in arsenic mitigation (Khan & Yang, 2012).

The installation of deep tubewells is comparatively simple, and may therefore provide fast, well-accepted mitigation for geographical regions where these are technically feasible. Furthermore, deep tubewells have been found less vulnerable to break compared to other options (Kabir & Howard, 2007). Naturally, deep tubewells must be tested for arsenic and other potentially hazardous substances (e.g. manganese, Hug et al., 2011) before opening them to the public. To ensure social acceptance, deep tubewells need to be installed in places that are easily accessible to women (Mosler et al., 2010), and the issue of distance to the wells needs to be addressed psychologically (e.g. by increasing commitment), and technically if required (e.g. by installing more wells). Finally, to ensure large-scale deep tubewell installation, consent of the GoB has to be sought and the national arsenic mitigation should be revised to prioritize deep tubewell installation over surface water options. Current research shows that reservations due to groundwater depletion (one of the reasons for not prioritizing groundwater) through drinking is not warranted (Ahmed et al., 2006). Moreover, the substitution of geogenic with microbial water quality issues of some surface water options (e.g. pond sand filters, dug wells) can be detrimental for disease burden (Howard et al., 2006). Furthermore, surface water options suffer from more acceptance issues (e.g. dug wells), as was shown by the present research.

To conclude, piped water supply and deep tubewells are promising approaches to arsenic mitigation in Bangladesh. However, their implementation depends on funding availability, technical capacity, and consensus of stakeholders, including the beneficiaries. Particularly since arsenic-safe shallow tubewells are available in many districts of Bangladesh, they provide an important further mitigation option that will be discussed next.

Enable and promote well-sharing

Arguably the cheapest and simplest arsenic-safe water option in Bangladesh is sharing existing arsenic-safe shallow tubewells. Technically, this option is viable in any location where arsenic-contamination is not too dense, so that enough arsenic-safe wells are present. This seems to be the case for a large proportion of the people at risk in Bangladesh (George, van Geen et al., 2012). No additional infrastructure is required, which is perhaps one reason why this option does not appear in stakeholder preferences (e.g. Khan & Yang, 2012), and is only implied, but not explicitly addressed in the GoB’s national policy of arsenic mitigation (GoB, 2004b). Despite its advantages, well-sharing requires intervention so people adopt this practice. The behavior change interventions developed in the present research were effective and low cost to enhance well-sharing among people who had already been aware of the contamination of their tubewells, and the presence of arsenic-safe wells in their vicinity. A further important target population is, however, people whose well status is unknown. In this case, well testing is the first step of mitigation.

While many people are aware of their well status due to the large screening campaign after the discovery of arsenic, millions of wells remain untested. The need for testing is further increased by the fact that new wells are continuously being installed (Ahmed et al., 2006). Opar and colleagues (2007) reported that the number wells even doubles every five years. Besides this, even arsenic-safe water options (e.g. deep tubewells, arsenic-removal filters) should be tested periodically (Ahmed et al., 2006). Finally, communicating well test results can itself spark behavior change, even though current research is equivocal on the extent of behavior change effect of this intervention (Lucas et al., 2011).

Regardless of behavior change impacts, people demand well testing, and results from a fee-based well-testing intervention showed that people in Bangladesh are also willing to pay for this service (George, Inauen, Rahman, & Zheng, 2012). To further encourage people to buy well tests, the interventions developed in this research may prove useful. Institutionally, establishing commercial well-testing facilities may be a possibility to gain stakeholders' interest in promoting well-sharing as a selling point for well tests. But more research is needed, particularly to assess people's willingness to pay for this service. In this regard, developing more accurate and low-cost methods for testing is a further issue.

Finally, while well-sharing, and deep tubewells are viable options for many regions in Bangladesh, they are not technically feasible everywhere. Furthermore, the widespread implementation of piped water supply will take time. It is therefore important to stress that any of the currently implemented water options can be promoted in order to enable immediate mitigation. Generally, community options emerged as more accepted than household water options, which is in line with previous research (e.g. Hanchett et al., 2002; Hoque et al., 2004; Khan & Yang, 2012). Where not enough water points are available, and distance therefore becomes an issue, people may even be encouraged to disinfect surface water, e.g. by SODIS. In fact, some participants in Study 3 of this research even started boiling their water. The importance here lies on the refinement of behavior change campaigns.

Improve behavior change interventions

It is being increasingly recognized that behavior change in arsenic mitigation is one of the top priorities (Ahmed et al., 2006; Khan & Yang, 2012; Lucas et al., 2011). However, although stakeholders claim that their main success in arsenic mitigation lies in creating awareness (Khan & Yang, 2012), systematic evaluations of behavior change campaigns are still the exceptions (see Tarozzi et al., 2009, for a good example). This research revealed several BCTs that were potent to increase switching to arsenic-safe wells, even in areas where safe water options were scarce. It is therefore recommendable that these BCTs, in particular reminders and implementation intentions, be included into existing behavior change campaigns. In order to further build a pool of evidence-based interventions that can increase the use of arsenic-safe water options, stakeholders need to unite efforts. This includes integrating evidenced BCTs into behavior change campaigns, systematic evaluation of the effectiveness of interventions, and sharing successful and failed interventions (including training manuals etc.) with fellow organizations. To achieve this, collaboration is a prerequisite, but the allocation of funding for developing and evaluating behavior change campaigns is essential. Furthermore, capacity building by behavior change professionals is a must, as the systematic development and evaluation requires expertise.

In the next section, the overall methods of this research will be critically appraised. Thereafter, final conclusions will be drawn.

5. Strengths and limitations

This study is the first strongly theory-based, quantitative and comprehensive study on the extent and determinants of arsenic-safe water consumption. It extends previous studies (Mosler et al., 2010; Shaw et al., 2005) regarding the range of arsenic-safe water options considered, the number of theory-based behavioral determinants taken into account, and the inclusion of field-experimental designs in addition to cross-sectional surveys. The consideration of several arsenic-safe water options provided a rare opportunity to formally assess the generalizability of the results, which was achieved with the behavioral model. In addition, the superior behavior change effects of reminders with information, and implementation intentions with reminders and information when compared to information alone were replicated for well-sharing and switching to arsenic-safe deep tubewells. This strongly indicates that the effectiveness of the developed interventions extends to other arsenic-safe water options as well. A further advantage of the parallel Studies 2 and 3 became evident at the appearance of the unexpected effects of public commitment with implementation intentions, reminders and information in Study 2. The fact that the studies differed in the effectiveness of this intervention indicates that this intervention must be further tested before it can be recommended for practical application. A further strength of this study is the rigorous application of theory in the process from developing to evaluating interventions (cf. Michie & Prestwich, 2010). While an increasing number of studies apply theory-based interventions to enhance health-behavior change, the formal test of the proposed mediating processes that was performed in this study is still a rarity. Overall, the results of this research therefore allows for strong implications for theory (Norman & Conner, 2005). Nevertheless, there are also critical issues that emerged. These may have implications for interpreting the results, and for the design of future studies. Issues of study design, sampling, and measures will be addressed as follows.

5.1. Study design

Behavioral determinants of arsenic-safe water consumption were mostly ascertained with cross-sectional designs in this research. From these, no conclusions on causality of the identified relationships between determinants and safe water consumptions can be drawn. The results of the longitudinal investigation (Chapter V) confirmed some of the associations found in the cross-sections (i.e. for vulnerability and commitment), whereas the impact of other determinants (e.g. descriptive norm) was not substantiated in the panel. It could be a next step to investigate the general model with a longitudinal survey design and see if the results from the cross-sections can be corroborated. Note that it requires a considerable sample size and therefore increased resources to do this, particularly as dropout must also be considered. For the baseline survey that was used to develop the interventions (Chapter IV), one could also argue that intervention planning from panel data would have been beneficial. However, as pointed out earlier, a longitudinal prior investigation would require more time and resources, which should be shown justified by added benefit. Nevertheless, when exploring a novel behavior, such as arsenic-safe water consumption, it may be worthwhile considering conducting a smaller, longitudinal pilot instead of a comprehensive cross-sectional study.

Other considerations refer to the cluster-randomized design for testing the developed interventions. First, clusters of geographically separated villages were chosen as the entity of randomization. This design was selected, because by randomized allocation of the interventions to single households information contamination between the intervention conditions would have been risked, particularly as some of the interventions were public (i.e. reminders on tubewells, public commitment). The disadvantage of cluster-randomized design is, however, that a further level is introduced into the data (i.e. the cluster). Although cluster-wise results were computed and they generally yielded similar results in the same intervention conditions, this was not formally taken into account in the analyses, i.e. by multilevel modeling. This was not possible, because multilevel analyses require a minimum of 30 clusters (Maas & Hox, 2005). Consequently, village-wise effects cannot be entirely ruled out. The replication of the intervention effects of Study 2 in Study 3, however, further increases confidence in the generalizability of the results. Still, future studies should employ randomized allocation wherever possible. Where this is not feasible (as will be mostly the case in the water and health domain), more clusters should be included that would allow for sophisticated consideration of the village-wise effects.

A further shortcoming in Studies 2 and 3 was the long lapse of more than two months between the baseline surveys and the implementation of the interventions. This was due to the fact that the interventions were not a priori defined but developed from the results of the baseline surveys. This required time. It is therefore possible that the effects presented in Chapters IV and V underestimate or overestimate the actual intervention effects, as changes caused by confounding variables (e.g. time) were unaccounted for. In subsequent investigations, it would therefore be recommendable to conduct another survey just before the intervention to control for these effects. In this regard, it would be further advantageous to include additional control groups; one group to control for interview effects, and a group with no intervention. For the former, a sub-sample could be interviewed for the first time at the second panel of the main sample. The control group without intervention may be important to control for changes over time that are not attributable to the intervention (e.g. well-switching due to broken wells). For the latter, ethical issues must be considered. A good solution may be to administer a placebo intervention, e.g. to administer basic information about another health issue that is unrelated to water. After the termination of the study, this group could further be delivered with the most effective intervention, as was done in the present study.

5.2. Samples

In Study 1, approximately 125 respondents for each arsenic-safe water option studies were included, which led to a total sample size of 872 households. This can be regarded as an adequate sample size for drawing conclusions regarding each water option, as was done in Chapter II. For the general model that included all participants, the large sample may have led to an increased Type I error, i.e. that negligible effects reached significance. As the results were largely confirmed with a smaller sample in Chapter IV, this does not seem to have been the case.

The baseline samples in Studies 2 and 3 were generally of adequate size. However, due to dropout and inadequate intervention delivery (or non-attendance), the sample sizes further decreased, particularly in some intervention groups (e.g. the public commitment condition in Study 3, see Chapter V). This may be a reason for some marginally significant effects (e.g. of the reminders+information intervention in Chapter V). Future studies should either further simplify their study designs to reduce the number of conditions, or recruit more participants at baseline. In fact, larger sample sizes were aimed at in the present study, but due to logistic issues this was not possible; the spatial heterogeneity led to an exclusion of large proportions of the surveyed communities. Particularly in Study 2, where approximately 50% of a given village owned arsenic-safe tubewells and were therefore not part of the target population. Although relatively large geographical areas were covered in the studies, no more than the surveyed participants were found in the areas. Future studies that investigate the same population should therefore aim at selecting even larger survey areas (e.g. an entire subdistrict), in order to locate more participants.

5.3. Measures

Most of the constructs were operationalized with established items derived from the literature. However, the items were adapted to the cultural context in Bangladesh and were translated into Bangla for the first time. While exploratory factor analyses corroborated the hypothesized item structures, confirmatory factor analyses would have provided stronger tests of validity of measures. As formal validation and reliability studies ideally require large item pools, and longitudinal data, this was not possible in the present study. But it may be worthwhile to test this in subsequent investigations, e.g. by employing the above recommended 2-wave pre-intervention assessment.

Another issue is social desirability, as self-reported data were used. This may have potentially biased the measurement of water consumption in particular. Methods for objective measurements of water consumption were considered. Possibilities are, for example, to measure arsenic contents of household drinking water by field test kits. This idea, however, was abandoned because the water test itself may have a reactive effect on behavior (cf. Lucas et al., 2011). Therefore, when applying this method, a further intervention period would have had to be considered, which was not possible in the present study due to constraints of time and resources. Furthermore, social desirability will not necessarily be reduced by this measure, as householders do not always have water available at home and may therefore go collect water outside when asked. Thus, they could go to the socially desirable well. Further considered were observations at the deep tubewells in Study 3. However, it is not common to have people sitting at wells in Bangladesh, as the water is free (i.e. no caretaker collecting fees), and often the wells are installed on private grounds. This would have therefore caused suspicion and perhaps would have kept women from collecting water from the safe wells. Probably the most reliable objective method would have been to collect urinary samples from all participants. However, this requires additional expertise and resources that was not available in the present research. Encouragingly, studies that measured urinary arsenic content have found its decrease due to self-reported well-switching (George, van Geen et al., 2012), indicating low bias in the self-reported data. This is in line with general doubts that participants may have been motivated to respond socially desirable at all. Many respondents demanded installation of arsenic-safe water points from us, wherefore the “smart” answer would actually have been to say they were currently consuming arsenic-contaminated water. Still, it is worthwhile considering assessing urinary data in future studies as they can also serve as a proxy of the interventions’ effects on the actual mitigation of accumulation of arsenic in the body and consequently improved health.

6. General conclusions

Most health threats, including water-borne diseases, can be prevented, mitigated or their effects ameliorated by personal behavior change. Yet, millions of people drink contaminated water, do not exercise regularly, they smoke, consume excessive alcohol or do not adhere to taking prescribed medicine. The social-cognitive approach assumes that these behaviors are a consequence of people’s cognitions. Moreover, it is proposed that these cognitions are modifiable and, when appropriately tackled, will lead to behavior change. These assumptions were tested in the present thesis for the example of safe water consumption. Social cognitions, in particular expectancies about what other people do, personal commitment to collect safe water, and the confidence in the personal ability to collect safe water, were able to explain and predict the use of arsenic-safe water options in Bangladesh. Interventions developed to modify the personal commitment to collect safe water not only increased the effectiveness of standard informational interventions to enhance the use of arsenic-safe wells. Moreover, it was also shown that the applied techniques indeed increased commitment, which in turn led to behavior change. Thereby, in theoretical relevance, commitment emerged as an important factor in behavior change. Practically, the results from this study, in line with accumulating evidence on other health behaviors, indicate the utility of theory-based interventions to increase safe water consumption, and possibly other health behaviors. The specific BCTs developed in this study can be used to enhance the adoption of arsenic-safe water options. In conclusion, the utility of the social cognition approach to health behavior change was corroborated in the present thesis. Hopefully, this will inspire more rigorous application of theory in every step of behavior change, not only by scientists, but also by health promotion practitioners, so the science and practice of behavior change can be advanced to ultimately increase people’s health and well-being.

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Appendix

Appendix I: Questionnaire example (English version)

Appendix II: Supplementary information Chapter III

Appendix III: Intervention materials

Appendix I: Questionnaire example (English version)

Social acceptance and use of arsenic mitigation options in Bangladesh

Baseline interviews October / November 2010 Questionnaire

B100	Arsenic Mitigation option:	1	Well-switching	2	Deep tubewell	3	Green tubewell owner
B101	User / Non-user:	1	Non-user	2	User		

B102 Number of households **who refused interview** before this household was interviewed:_______ No. of HH

Please interview the person of the household that is responsible for the water for the family!

Introduction

Please introduce yourself!

Hello, my name is ………………………….. and I am working for Eawag, the Swiss Federal Institute of Aquatic Science and Technology. We are conducting a research study on household water consumption. If you don't mind, I would like to interview you about your water consumption preferences. It will take about 45 minutes. Do you have the time for the interview? We are also interviewing other households in your community as well as other communities in Bangladesh. The results will be treated anonymously. We are not interested in any particular answers, just in the answers that really represent your opinion. We would like to know why people are doing what they are doing so that we can improve the drinking water situation depending on this information. It helps us most if you answer as honest and properly as possible. Please help us in finding out how things really are!

General information regarding the interview

Start time: ....

B103	ID number:						
B104	Date of the interview:	2010		(month / day)			
B105	Interviewer Name:					Interviewer ID No.:	
B106	District:	1	Manikgonj	2	Comilla		
B107	Upazila:	1	Shibaloya	2	Monoharganj		
B108	Union:	1	Arua	4	Uthali	7	
		2	Mohadevpur	5		8	
		3	Teota	6		9	
B109	Ward Number:						
B110	Village:	1	Choto Dhutabari	11	Darikandi (Mohadevpur)	21	Bardhamankandi
		2	Darikandi (Arua)	12	Kuarbil	22	Brahmankol
		3	Dhilpur	13	Sahili	23	Dhusar
		4	Nali	14	Sarasin	24	Mahidpur
		5	Baulikanda	15	Bhubulia	25	Sasinara
		6	Dakhin Shaljana	16	Goalia	26	
		7	Ghonapara	17	Nehalpur	27	
		8	Jagadia	18	Paila	28	
		9	Kushtia	19	Teota Baset	29	
		10	Bara Bhabanipur	20	Bahulakol	30	

Water Consumption

B200 Which of the following water sources are available to you? ***(Multiple choice! Don't read this list!)***

1	Own green tubewell	6	Neighbor's untested tubewell	11	Dug well
2	Own red tubewell	7	Deep tubewell	12	Rain-water Harvesting
3	Own untested tubewell	8	Pond sand filter	13	Piped water supply
4	Neighbor's green tubewell	9	Sidko plant	14	Pond / river water (untreated)
5	Neighbor's red tubewell	10	Household filter (SONO, Alcan, Read-F)	15	Other:

B201 How sure are you that your tubewell is green / red / untested ***(--> Interviewer select appropriate from answer above!)***:

1	Not at all sure	3	Rather sure	5	Very sure
2	Not sure	4	Sure	777	Doesn't own a tubewell

How much water from the following water sources did you use for drinking and cooking in any typical day in last week?

Interviewer: *Ask the respondent to show you, which vessel he or she uses for drinking.*

B202 Estimated contents of the vessel used for **drinking** *(interviewer estimate):* .... liters.

Interviewer: *Ask the respondent to show you, which vessel he or she uses for pouring water for cooking.*

B203 Estimated contents of the vessel used for **pouring water for cooking** *(interviewer estimate):* .... liters.

Please only fill in the first column of the tables (number of vessels).	***B204*** How many vessels of the following water sources do you and others living in your household **drink on a typical day**?			***B205*** How many vessels of the following water sources do you and others living in your household **use for cooking on a typical day**?			***B206*** How much water from the following water sources did you use for drinking **in the last three days**?		
	Vessels *1*	**Liters** *2*	**(%)** *3*	**Vessels** *1*	**Liters** *2*	**(%)** *3*	*Number of vessels* Yesterday	2 days ago	3 days ago
_1 ***Total:***			100			100			
_2 Neighbors green/ arsenic free STW									
_3 Own green / arsenic free STW									
_4 DTW									
_5 HH arsenic removal filter (sono, alcan, read-f)									
_6 Community arsenic filter (SIDKO)									
_7 Pond sand filter									
_8 Dugwell									
_9 Piped water supply system									
_10 HH Rainwater Harvesting									
_11 Community Rainwater Harvesting									
_12 Bottled water									
_13 Red/arsenic contaminated STW									
_14 Untested STW									
_15 Pond/river/cannel (unfiltered)									
_16 Other (specify):									

B207 Which water do you prefer for drinking? The water from… ***(only 1 choice!)***

1	Green shallow tubewell	5	Pond sand filter	9	Rainwater Harvesting
2	Red shallow tubewell	6	Sidko plant	10	Piped water supply
3	Untested shallow tubewell	7	Household filter (Sono, Alcan, Read-F)	11	Pond / river water (untreated)
4	Deep tubewell	8	Dug well	12	Other:

B208 Which water do you prefer for cooking? The water from… ***(only 1 choice!)***

1	Green shallow tubewell	5	Pond sand filter	9	Rain-water Harvesting
2	Red shallow tubewell	6	Sidko plant	10	Piped water supply
3	Untested shallow tubewell	7	Household filter (Sono, Alcan, Read-F)	11	Pond / river water (untreated)
4	Deep tubewell	8	Dug well	12	Other:

Water from the contaminated / untested shallow tubewell

In case respondent still consumes water from red or untested shallow tubewell (for drinking or cooking):
If respondent does not consume any water from red or untested shallow tubewell, go to B301.

B300 Why do you consume water from the red or untested shallow tubewell?
(don't read this list! Multiple choice)

1	It's available nearby	7	Water is less saline	13	Taste of water from arsenic mitigation option is not good
2	It's less effortful to collect	8	Others also collect water from there	14	No arsenic-safe water option is nearby
3	It requires less time to collect	9	Others want me to collect water from there	15	In availabiility of water all the time from arsenic mitigation option
4	The water tastes better	10	Decission of HH head	16	Good water quality (unspecific)
5	The temperature is nicer	11	To avoid problems with owner / neighbor / caretaker	17	Other:
6	Water contains less iron	12	To avoid payment for using arsenic safe water option(s)	777	Not applicable

Advantages and disadvantages of **collecting water from the contaminated / untested tubewell**

a) What are the advanatages and disadvantages of collecting water from the red / contaminated shallow tubewell?
Is there anything particularly good or bad regarding the... (***read headings below!***).

	_1 **Openly mentioned?**	*_2* **Intensity**	*_3* **How good or bad do you find this advantage or disadvantage?**								
			Rather bad			**Rather neutral**			**Rather good**		
			1 very bad	**2 bad**	**3 quite bad**	**4 rathr bad**	**5 neither**	**6 rathr good**	**7 quite good**	**8 good**	**9 very good**
... quality of this water for drinking and cooking?											
B301 Taste	1 = no 2 = yes	1 = much 2 = little/none	1	2	3	4	5	6	7	8	9
B302 Smell	1 = no 2 = yes	1 = much 2 = little/none	1	2	3	4	5	6	7	8	9
B303 Color	1 = no 2 = yes	1 = very red 2 = little red	1	2	3	4	5	6	7	8	9
B304 Temperature	1 = no 2 = yes	1 = warm 2 = cold	1	2	3	4	5	6	7	8	9
B305 Iron	1 = no 2 = yes	1 = much 2 = little/none	1	2	3	4	5	6	7	8	9
B306 Salinity	1 = no 2 = yes	1 = much 2 = little/none	1	2	3	4	5	6	7	8	9

B307 Other:	1 = no 2 = yes	1 = much 2 = little/none	1	2	3	4	5	6	7	8	9
... health or diseases?											
B308 Arsenic	1 = no 2 = yes	1 = much 2 = little/none	1	2	3	4	5	6	7	8	9
B309 Dirt	1 = no 2 = yes	1 = much 2 = little/none	1	2	3	4	5	6	7	8	9
B310 Produces diarrhea	1 = no 2 = yes	1 = much 2 = little/none	1	2	3	4	5	6	7	8	9
B311 Other:	1 = no 2 = yes	1 = much 2 = little/none	1	2	3	4	5	6	7	8	9
	_1 **Openly mentioned?**	*_2* **Intensity**	*_3* **How good or bad do you find this advantage or disadvantage?**								
			Rather bad			**Rather neutral**			**Rather good**		
			1 very bad	**2 bad**	**3 quite bad**	**4 rathr bad**	**5 neith er**	**6 rathr good**	**7 quite good**	**8 good**	**9 very good**
... effort related to collecting this water?											
B312 Distance	1 = no 2 = yes	1 = far 2 = close	1	2	3	4	5	6	7	8	9
B313 Time to collect	1 = no 2 = yes	1 = much 2 = little/none	1	2	3	4	5	6	7	8	9
B314 Physical effort	1 = no 2 = yes	1 = much 2 = little/none	1	2	3	4	5	6	7	8	9
B315 Costs	1 = no 2 = yes	1 = much 2 = little/none	1	2	3	4	5	6	7	8	9
B316 Restriction to collect	1 = no 2 = yes	1 = many 2 = little/none	1	2	3	4	5	6	7	8	9
B317 Other:	1 = no 2 = yes	1 = much 2 = little/none	1	2	3	4	5	6	7	8	9
... people you meet when collecting this water?											
B318 Meet other people	1 = no 2 = yes	1 = many 2 = little/none	1	2	3	4	5	6	7	8	9
B319 Others see me	1 = no 2 = yes	1 = many 2 = little/none	1	2	3	4	5	6	7	8	9
B320 Other:	1 = no 2 = yes	1 = much 2 = little/none	1	2	3	4	5	6	7	8	9
... any other advantages or disadvantages?											
B321 Other: __________	1 = no 2 = yes	1 = much 2 = little/none	1	2	3	4	5	6	7	8	9

B322 How much do you feel that you fetch water from the red / contaminated shallow tubewell as a matter of habit? Fetching water from the shallow tubewell is...

1	Not at all a habit	2	a weak habit	3	medium strong habit	4	a strong habit	5	a very strong habit

B323 Do you go to collect water from the red / untested tubewell automatically?

1	No, not at all automatically	3	Quite automatically	5	Very automatically
2	Not automatically	4	Automatically		

B324 When do you normally go to collect water from the red / untested tubewell? ***(Multiple choice)***

1	As needed	5	Before lunch	9	Evening
2	Before eating	6	Morning time	10	Night
3	After cooking	7	Midday	11	Other
4	Before breakfast	8	Afternoon		

B325 How often do you go to collect water from the red / untested tubewell at these moments?

1	(Almost) never	2	Seldom	3	Sometimes	4	Often	5	(Almost) always

B326 How often do you collect water from the shallow tubewell per day? ______________ times.

B327 How much do you like or dislike the **taste** of water from the red tubewell / untested tubewell?

rather dislike it		rather neutral		rather like it	
1	I dislike it very much	4	I rather dislike it	7	I quite like it
2	I dislike it	5	I neither dislike it nor do I like it	8	I like it
3	I quite dislike it	6	I rather like it	9	I like it very much

B328 How much do you like or dislike the **temperature** of water from the red tubewell / untested well?

rather dislike it		rather neutral		rather like it	
1	I dislike it very much	4	I rather dislike it	7	I quite like it
2	I dislike it	5	I neither dislike it nor do I like it	8	I like it
3	I quite dislike it	6	I rather like it	9	I like it very much

B329 How much do you like or dislike the **color** of water from the red tubewell / untested tubewell?

rather dislike it		rather neutral		rather like it	
1	I dislike it very much	4	I rather dislike it	7	I quite like it
2	I dislike it	5	I neither dislike it nor do I like it	8	I like it
3	I quite dislike it	6	I rather like it	9	I like it very much

B330 How long does it take to collect water from the red / contaminated tubewell ***(going and back)***? _____ min.

B331 Do you think that collecting water from red / untested tubwell is **time-consuming**?

1	Not at all time-consuming	2	Not time-consuming	3	A little time-consuming	4	Time-consuming	5	Very time-consuming

B332 Do you think that collecting water from red / untested tubwell is **effortful**?

1	Not at all effortful	2	Not effortful	3	A little effortful	4	Effortful	5	Very effortful

Introduction: all of the following can be effortful sometimes. Please tell me**, how effortful** you find these and **how often they occur**. ***(go through them, one by one!)***

	_1 **How effortful is it?**					*_2* **How often does this happen?**				
	1 not effortful	**2 a little effortful**	**3 rather effortful**	**4 effortful**	**5 very effortful**	**1 almost never**	**2 seldom**	**3 some-times**	**4 often**	**5 almost always**
B333 Long distance	1	2	3	4	5	1	2	3	4	5
B334 Spending time	1	2	3	4	5	1	2	3	4	5
B335 Waiting time	1	2	3	4	5	1	2	3	4	5
B336 Physical: walking to well	1	2	3	4	5	1	2	3	4	5
B337 Physical: pumping the well	1	2	3	4	5	1	2	3	4	5
B338 Self willingness	1	2	3	4	5	1	2	3	4	5
B339 Keep in mind	1	2	3	4	5	1	2	3	4	5
B340 Be patient	1	2	3	4	5	1	2	3	4	5
B341 Be punctual	1	2	3	4	5	1	2	3	4	5

B342 Planning to collect water	1	2	3	4	5	1	2	3	4	5
B343 Pay for using	1	2	3	4	5	1	2	3	4	5
B344 Share maintenance cost	1	2	3	4	5	1	2	3	4	5
B345 Maintain shallow tubewell	1	2	3	4	5	1	2	3	4	5
B346 Maintain good relationship with neighbor / owner / caretaker	1	2	3	4	5	1	2	3	4	5
*B347*Other: ____________________	1	2	3	4	5	1	2	3	4	5

B348 **In the last month,** how long were you not able to use the red / untested tubewell because it was broken?_______days.

B349 How good or bad would you say is it to drink water from a red tubewell / untested tubewell?

rather bad		rather neutral		rather good	
1	Very bad	4	A little bit bad	7	Quite good
2	Bad	5	Neither good nor bad	8	Good
3	Quite bad	6	A little good	9	Very good

B350 Considering all the benefits and efforts related to collecting your water from red / untested tubwell, how much do you think is it worthwhile to collect your water from red / untested tubwell?

Rather more effort than benefit		Rather neutral		Rather higher benefit than effort	
1	It costs much more effort than benefit	4	It costs slightly more effort than benefit	7	The benefit is quite higher than the effort
2	It costs more effort than benefit	5	The effort and the benefit are about the same	8	The benefit is higher than the effort
3	It costs quite more effort than benefit	6	The benefit is slightly higher than the effort	9	The benefit is very much higher than the effort

B351 How much do you like or dislike collecting water from red / untested tubwell?

rather dislike it		rather neutral		rather like it	
1	I dislike it very much	4	I rather dislike it	7	I quite like it
2	I dislike it	5	I neither dislike it nor do I like it	8	I like it
3	I quite dislike it	6	I rather like it	9	I like it very much

B352 How pleasant or unpleasant is it for you fetch water from the red / contaminated shallow tubewell?

rather unpleasant		rather neutral		rather pleasant	
1	Very unpleasant	4	rather unpleasant	7	quite plesant
2	unpleasant	5	neiter pleasant nor unpleasant	8	pleasant
3	quite unpleasant	6	rather pleasant	9	very pleasant

B353 How positive or negative do you think is it to collect water from the red / contaminated shallow tubewell?

rather negative		rather neutral		rather positive	
1	very negative	4	rather negative	7	quite positive
2	negative	5	neither negative nor positive	8	positive
3	quite negative	6	rather positive	9	very positive

B354 How proud or ashamed are you to drink water from the red / untested shallow tubewell?

rather ashamed		rather neutral		rather proud	
1	Very ashamed	4	Rather ashamed	7	Quite proud
2	Ashamed	5	Neither ashamed nor proud	8	Proud
3	Quite ashamed	6	Rather proud	9	Very proud

B355 How many people outside your family drink water from a red tubewell / untested tubewell?

1	(Almost) nobody (0%)	3	Half of them (50%)	5	(Almost) all (100%)
2	Some of them (25%)	4	Most of them (75%)		

B356 How many people of your relatives, excluding people of your household, drink water from a red tubewell / untested tubewell?

1	(Almost) nobody (0%)	3	Half of them (50%)	5	(Almost) all (100%)
2	Some of them (25%)	4	Most of them (75%)		

B357 How proud or ashamed are you to offer water from red / untested tubwell to your guests?

rather ashamed		rather neutral		rather proud	
1	Very ashamed	4	Rather ashamed	7	Quite proud
2	Ashamed	5	Neither ashamed nor proud	8	Proud
3	Quite ashamed	6	Rather proud	9	Very proud

B358 How high or low are the chances that you develop an illness when drinking water from a red tubewell / untested tubewell?

Rather low		Rather average		Rather high	
1	Very low	4	rather low	7	quite high
2	low	5	average	8	high
3	quite low	6	rather high	9	very high

B359 In general, how difficult or easy is it to collect water from red / untested tubwell?

Rather difficult		Rather neutral		Rather easy	
1	Very difficult	4	Rather difficult	7	Quite easy
2	Difficult	5	Neither easy nor difficult	8	Easy
3	Quite difficult	6	Rather easy	9	Very easy

B360 More specifically, how difficult or easy is it to find time to collect water from red / untested tubwell?

Rather difficult		Rather neutral		Rather easy	
1	Very difficult	4	Rather difficult	7	Quite easy
2	Difficult	5	Neither easy nor difficult	8	Easy
3	Quite difficult	6	Rather easy	9	Very easy

B361 More specifically, how difficult or easy is it to get as much water as you need from red / untested tubwell?

Rather difficult		Rather neutral		Rather easy	
1	Very difficult	4	Rather difficult	7	Quite easy
2	Difficult	5	Neither easy nor difficult	8	Easy
3	Quite difficult	6	Rather easy	9	Very easy

B362 How sure are you that you can stop drinking water from the red / untested tubewell altogether?

1	Not at all sure	3	Rather sure	5	Very sure
2	Not sure	4	Sure		

B363 You drink water from an untested/ red tubewell. Do people who are important to you rather approve or disapprove of this ***(for non-users: Suppose you drink water from the contaminated shallow tubewell)***.

Rather disapprove		Rather neutral		Rather approve	
1	Nearly all disapprove	4	Rather more approve	7	Significantly more approve
2	Most disapprove	5	The same amount disapprove and approve	8	Most approve
3	Significantly more disapprove	6	Rather more approve	9	Nearly all approve

B364 You DO NOT drink water from an untested/ red tubewell. Do people who are important to you rather approve or disapprove of this ***(for users: Suppose you stop driningk water from the contaminated STW)***.

Rather disapprove		Rather neutral		Rather approve	
1	Nearly all disapprove	4	Rather more approve	7	Significantly more approve
2	Most disapprove	5	The same amount disapprove and approve	8	Most approve
3	Significantly more disapprove	6	Rather more approve	9	Nearly all approve

B365 Overall, how much would people who are important to you approve or disapprove that/if you drink water from a red / untested tubewell?

Rather disapprove		Rather neutral		Rather approve	
1	They would disapprove very much	4	They would rather disapprove	7	They would quite approve
2	They would disapprove	5	They would neither approve nor disapprove	8	They would approve
3	They would quite disapprove	6	They would rather approve	9	They would approve very much

B366 Overall, how much would people who are important to you approve or disapprove that/if you DO NOT drink water from a red / untested tubewell?

Rather disapprove		Rather neutral		Rather approve	
1	They would disapprove very much	4	They would rather disapprove	7	They would quite approve
2	They would disapprove	5	They would neither approve nor disapprove	8	They would approve
3	They would quite disapprove	6	They would rather approve	9	They would approve very much

Use of Neighbour's Green Tubewell / Deep Tubewell

This and the following section concern the use and attitudes towards the neighbor's green shallow tubewell / the deep tubewell. If the respondent has never used the mitigation option, she or he should try to answer the questions by imaginining the neighbor's green tubewell / the deep tubewell that is closest to her / him.

If the respondent has never used the mitigation option: go to <u>B408</u>.

B400 If respondent drinks water from mitigation option: Why do you consume water from your neighbor's green tubewell / the deep tubewell? ***(don't read this list! Multiple choice)***

1	The water contains less (is free of arsenic	7	Others also collect water from there	13	The water is healthy
2	It's available nearby	8	Others want me to collect water from there	14	The color of the water is nice
3	It's less effortful to collect	9	The water contains less iron	15	The color of the cooked food is nice
4	It requires less time to collect	10	The water is less saline	16	It's free of cost

5	The water tastes better	11	To avoid problems with caretaker / neighbor	17	It's cheap
6	The temperature is nicer	12	Good water quality (unspecific)	18	Other:
777	Not applicable				

B401 ***If respondent drinks water from mitigation option:*** How many times **did you go** to collect water from your neighbor's green tubewell / the deep tubewell in the last week? (number of times)

Day:	1	2	3	4	5	6	7	Total / week
No. of times:								
777	not appl.							

During the last week ...

B402 … How much did you pay attention so you **don't forget** to collect water from the mitigation option?

1	No attention at all	2	Little attention	3	Some attention	4	Attention	5	Much attention
777	Not applicable								

B403 ... How much did you watch yourself to collect **sufficient** water from the mitigation option for drinking and cooking for your family?

1	Not at all	2	Little	3	Some	4	Much	5	Very much
777	Not applicable								

B404 … How often did you remember your good **intentions** to collect water from mitigation option?

1	(Almost) never	2	Seldom	3	Sometimes	4	Often	5	(Almost) always
777	Not applicable								

B405 ... How aware were you of your **goal** to collect water from the mitigation option.

1	Not at all aware	2	Little aware	3	Rather aware	4	Aware	5	Very much aware
777	Not applicable								

B406 … How strongly did you try to to collect **all** of our drinking water from the migiation option?

1	Not at all	2	Little bit	3	Rather strongly	4	Strongly	5	Very strongly
777	Not applicable								

B407 … How strongly did you try to **make time** to collect water from the mitigation option every day?

1	Not at all	2	Little bit	3	Rather strongly	4	Strongly	5	Very strongly
777	Not applicable								

B408 In total, how often per day **do you (would you) need to** collect water from the deep tubewell in order to get all of your water for drinking and cooking from your neighbor's tubewell / the deep tubewell?

________ times per day.

Advantages and disadvantages of **collecting water from the mitigation option**

a) What are the advantages and disadvantages of collecting water from the mitigation option? Is there anything particularly good or bad regarding the... **(*read headings below!*).**

	_1 **Openly mentioned?**	_2 **Intensity**	_3 **How good or bad do you find this advantage or disadvantage?**								
			Rather bad			**Rather neutral**			**Rather good**		
			1 very bad	**2 bad**	**3 quite bad**	**4 rathr bad**	**5 neith er**	**6 rathr good**	**7 quite good**	**8 good**	**9 very good**
... quality of this water for drinking and cooking?											
B409 Taste	1 = no 2 = yes	1 = much 2 = little/none	1	2	3	4	5	6	7	8	9
B410 Smell	1 = no 2 = yes	1 = much 2 = little/none	1	2	3	4	5	6	7	8	9
B411 Color	1 = no 2 = yes	1 = very red 2 = little red	1	2	3	4	5	6	7	8	9
B412 Temperature	1 = no 2 = yes	1 = warm 2 = cold	1	2	3	4	5	6	7	8	9
B413 Iron	1 = no 2 = yes	1 = much 2 = little/none	1	2	3	4	5	6	7	8	9
B414 Salinity	1 = no 2 = yes	1 = much 2 = little/none	1	2	3	4	5	6	7	8	9
B415 Other: __________	1 = no 2 = yes	1 = much 2 = little/none	1	2	3	4	5	6	7	8	9
... health or diseases?											
B416 Arsenic	1 = no 2 = yes	1 = much 2 = little/none	1	2	3	4	5	6	7	8	9
B417 Dirt	1 = no 2 = yes	1 = much 2 = little/none	1	2	3	4	5	6	7	8	9
B418 Produces diarrhea	1 = no 2 = yes	1 = much 2 = little/none	1	2	3	4	5	6	7	8	9
B419 Other: __________	1 = no 2 = yes	1 = much 2 = little/none	1	2	3	4	5	6	7	8	9
... effort related to collecting this water?											
B420 Distance	1 = no 2 = yes	1 = far 2 = close	1	2	3	4	5	6	7	8	9
B421 Time to collect	1 = no 2 = yes	1 = much 2 = little/none	1	2	3	4	5	6	7	8	9
B422 Physical effort	1 = no 2 = yes	1 = much 2 = little/none	1	2	3	4	5	6	7	8	9
B423 Costs	1 = no 2 = yes	1 = much 2 = little/none	1	2	3	4	5	6	7	8	9
B424 Restriction to collect	1 = no 2 = yes	1 = many 2 = little/none	1	2	3	4	5	6	7	8	9
B425 Other: __________	1 = no 2 = yes	1 = much 2 = little/none	1	2	3	4	5	6	7	8	9
... people you meet when collecting this water?											
B426 Meet other people	1 = no 2 = yes	1 = many 2 = little/none	1	2	3	4	5	6	7	8	9
B427 Others see me	1 = no 2 = yes	1 = many 2 = little/none	1	2	3	4	5	6	7	8	9
B428 Other: __________	1 = no 2 = yes	1 = much 2 = little/none	1	2	3	4	5	6	7	8	9
... any other advantages or disadvantages?											
B429 Other: __________	1 = no 2 = yes	1 = much 2 = little/none	1	2	3	4	5	6	7	8	9

B430 How much do you feel that you fetch water from the mitigation option as a matter of habit? Fetching water at the mitigation option is...

1	2	3	4	5
Not at all a habit	a weak habit	medium strong habit	a strong habit	a very strong habit

B431 Do you go to collect water from mitigation option automatically?

1	2	3	4	5
No, not at all automatically	Not automatically	Quite automatically	Automatically	Very automatically

B432 When do you normally go to collect water from mitigation option? ***(multiple answers possible)***

1	As needed	5	Before lunch	9	Evening
2	Before take food	6	Morning time	10	Night
3	After cooking	7	Midday	11	Other
4	Before breakfast	8	Afternoon		

B433 How often do you go to collect water from mitigation option at these moments?

1	(Almost) never	2	Seldom	3	Sometimes	4	Often	5	(Almost) always

B434 How important is it for you to present water from mitigation option to your guests?

1	Not at all important	2	Not important	3	Little bit important	4	Important	5	Very important

B435 How proud or ashamed are you to offer water from mitigation option to your guests?

Rather ashamed		Rather neutral		Rather proud	
1	Very ashamed	4	Rather ashamed	7	Quite proud
2	Ashamed	5	Neither ashamed nor proud	8	Proud
3	Quite ashamed	6	Rather proud	9	Very proud

B436 What would your guests think of you if you did not have water from mitigation option?

Rather badly		Rather neutral		Rather well	
1	They would think very badly of me	4	They would think a little badly of me	7	They would think quite well of me
2	They would think badly of me	5	They would think neither well nor badly of me	8	They would think well of me
3	They would think quite badly of me	6	They would think a little well of me	9	They would think very well of me

B437 How strongly do you intend to **always** collect water from mitigation option?

1	Not at all	2	Not	3	A little	4	Strongly	5	Very strongly

B438 How strongly do you intend to collect **all** your drinking water from the mitigation option?.

1	Not at all	2	Not	3	A little	4	Strongly	5	Very strongly

B439 How much do other habits hinder you to collect your water from mitigation option?

1	Not at all	2	A little	3	Medium	4	Much	5	Very much

B440 *What are the habits that hinder you? (e.g. taking water from the shallow well)*

....

.

....

B441 How difficult is it to remember going to collect water from mitigation option?

1	Very difficult	2	Difficult	3	Medium	4	Not so difficult	5	Not difficult at all

B442 How often does it happen that you forget to go to collect water from mitigation option?

1	(Almost) never	2	seldom	3	sometimes	4	often	5	(Almost) always

B443 How often did you forget to go to collect water from mitigation option in the last week? ________ times.

B444 Is there something which helps you remember to collect water from mitigation option?

1	No	2	Yes

If yes: How much are the following helping you in remembering to collect water from the mitigation option?

	Not helpful	A little bit helpful	Rather helpful	Quite helpful	Helpful	Very helpful	Not applicab le
B445 Head of household	1	2	3	4	5	6	777
B446 Other household member	1	2	3	4	5	6	777
B447 Relative	1	2	3	4	5	6	777
B448 Neighbor	1	2	3	4	5	6	777
B449 Muezzin	1	2	3	4	5	6	777
B450 Empty kalosh	1	2	3	4	5	6	777
B451 Before eating	1	2	3	4	5	6	777
B452 Before cooking	1	2	3	4	5	6	777
B453 Seeing the position of sun	1	2	3	4	5	6	777
B454Other: ______________	1	2	3	4	5	6	777

B455 How important is it for you to collect water from mitigation option?

1	Not at all important	2	Not important	3	Little bit important	4	Important	5	Very important

B456 Do you feel committed to collect water from mitigation option?

1	Not at all	2	A little	3	Medium	4	Much	5	Very much

B457 How annoyed do you feel if you forget to collect water from mitigation option?

1	Not at all	2	A little	3	Medium	4	Much	5	Very much

B458 How often does it happen to you that you want to collect water from mitigation option but then you prefer to do something else?

1	(Almost) never	2	Seldom	3	Sometimes	4	Often	5	Almost always

B459 If B458 > 1: What is it that you prefer to do in these moments (instead of collecting water)?

1	Household works	2	Take care of baby	3	Food intake	4	Other:	777	Not applicable

B460 How sure are you that you can collect as much arsenic free water from mitigation option as you need?

1	Not at all sure	3	Rather sure	5	Very sure
2	Not sure	4	Sure		

	1 Not at all confident	2 Not confident	3 A little confident	4 Confident	5 Very confident
How confident are you that you can resist drinking water from the contaminated shallow tubewell?					
B461 ... even if your relatives continue to consume water from the contaminated shallow tubewell?	1	2	3	4	5
B462 ... even if you have to walk a long distance to reach the next safe tubewell?	1	2	3	4	5
How confident are you that you can collect arsenic free water regularly?					
***B463* …** even if the arsenic mitigation option where you normally collect your water from is broken?	1	2	3	4	5
***B464* …** even if you don't feel like going to collect water?	1	2	3	4	5
***B465* …** even if the neighbor / owner / caretaker behaves rudely to you?	1	2	3	4	5
B466 Imagine you occasionally don't go to collect water from the mitigation option. How confindent are you about collecting water from the mitigation option regularly again?	1	2	3	4	5
B467 Imagine you stopped going to collect water from the mitigation option for **several days** (e.g. because it was broken). How confident are you to start collecting water from the mitigation option again?	1	2	3	4	5
B468 Imagine you stopped going to collect water from the mitigation option for **several weeks** (e.g. because it was broken). How confident are you to start collecting water from the mitigation option again?	1	2	3	4	5

B469 - B474: Only for people who are currently not using the mitigation option.

B469 When during the day will you start to collect water?

1	No plan yet	3	Midday	5	Evening	777	Not applicable (N/A)
2	Morning	4	Afternoon	6	Other:		

B470 When will you start to collect water?

1	No plan yet	3	Within 1 week	5	Within 1 month	777	Not applicable (N/A)
2	Tomorrow	4	Within 2 weeks	6	Other:		

B471 Which arsenic-safe water option will you start collecting your water from?

1	No plan yet	3	Neighbor's green tubewell	777	Not applicable (N/A)
2	Deep tubewell	4	Other mitigation option:		

Do you have a detailed plan regarding…		**1** **No detailed plan at all**	**2** **No detailed plan**	**3** **Quite detailed plan**	**4** **Detailed plan**	**5** **Very detailed plan**	**777** **Not applicable**
B472	when during the day to start collecting water from mitigation option.	1	2	3	4	5	777
B473	from when on to start collecting water from mitigation option.	1	2	3	4	5	777
B474	which mitigation option to collect my water from.	1	2	3	4	5	777

Do you have a detailed plan regarding…		**1** **No detailed plan at all**	**2** **No detailed plan**	**3** **Quite detailed plan**	**4** **Detailed plan**	**5** **Very detailed plan**
B475	what to do when the mitigation option gets broken.	1	2	3	4	5
B476	how to avoid forgetting to collect water from mitigation option.	1	2	3	4	5
B477	what to do when other urgent tasks arise and impair my going to collect water from the mitigation option.	1	2	3	4	5

B478 How long does it take to collect water from your neighbor's tubewell / DTW_______minutes ***(going and back).***

B479 Last month, how long were you not able to use the mitigation option because it was broken (days)?_____days.

B480 ***If B479 > 0:*** Why did it take a long time to make the repair(s) or why was the option not repaired?

1	Economical problem	5	Repairing is effortful	9	Lack of initiative / importance
2	Repairing is expensive	6	Low availability of parts	10	Other:
3	Nobody likes share repairing cost	7	Lack of repairing workers	777	Not applicable
4	Repairing is time-consuming	8	Lack of knowledge	888	I don’t know

Attitudes and norms regarding the neighbor’s green tubewell / Deep Tubewell

Difficulties related to collecting water from the mitigation option: **What are the difficulties** may hinder you in collecting water from the mitigation option?
How **often** do these difficulties occur? **What can you do** to overcome these difficulties? How **good or bad** are those activities to overcome these difficulties?
Interviewer: please go through each difficulty listed in the table.

	_1 **Openly mentioned?**	*_2* **How often does this happen?**	*_3* **What can you do to overcome this difficulty?**	*_4* **How good or bad do you find this activity to overcome this difficulty?**								
		1 = almost never **2 = seldom** **3 = sometimes** **4 = often** **5 = almost always**	1 = use different well 2 = talk to neighbor/ owner/caret. 3 = save money 4 = repair option 5 = plan water collection into daily routine 6 = go to collect when less people at well 7 = go in groups to collect water 9 = boil surface water 10 = Other (specify!)	**1 very bad**	**2 bad**	**3 quite bad**	**4 rathr bad**	**5 neither**	**6 rathr good**	**7 quite good**	**8 good**	**9 very good**
B500 Bad relationship with neighbor / owner / caretaker	1 = no 2 = yes			1	2	3	4	5	6	7	8	9
B501 Frequency of water collection restricted neighbor/owner/ caret.	1 = no 2 = yes			1	2	3	4	5	6	7	8	9
B502 Collecting water from others’ house is shameful	1 = no 2 = yes			1	2	3	4	5	6	7	8	9
B503 Going outside is bad for women	1 = no 2 = yes			1	2	3	4	5	6	7	8	9
B504 Fee for collecting water	1 = no 2 = yes			1	2	3	4	5	6	7	8	9
B505 Well is broken	1 = no 2 = yes			1	2	3	4	5	6	7	8	9
B506 Long distance	1 = no 2 = yes			1	2	3	4	5	6	7	8	9
B507 Much time to walk	1 = no 2 = yes			1	2	3	4	5	6	7	8	9
B508 Long waiting-time	1 = no 2 = yes			1	2	3	4	5	6	7	8	9
B509 Much physical effort	1 = no 2 = yes			1	2	3	4	5	6	7	8	9
B510 Salinity problem	1 = no 2 = yes			1	2	3	4	5	6	7	8	9
B511 Microbial contamination	1 = no 2 = yes			1	2	3	4	5	6	7	8	9
B512 Forgetting to collect water	1 = no 2 = yes			1	2	3	4	5	6	7	8	9
B513 Other:	1 = no 2 = yes			1	2	3	4	5	6	7	8	9

B514 How much do you like or dislike the **taste** of water from mitigation option?

Rather dislike it		Rather neutral		Rather like it	
1	I dislike it very much	4	I rather dislike it	7	I quite like it
2	I dislike it	5	I neither dislike it nor do I like it	8	I like it
3	I quite dislike it	6	I rather like it	9	I like it very much

B515 How much do you like or dislike the **temperature** of water from mitigation option?

Rather dislike it		Rather neutral		Rather like it	
1	I dislike it very much	4	I rather dislike it	7	I quite like it
2	I dislike it	5	I neither dislike it nor do I like it	8	I like it
3	I quite dislike it	6	I rather like it	9	I like it very much

B516 How much do you like or dislike the **color** of water from mitigation option?

Rather dislike it		Rather neutral		Rather like it	
1	I dislike it very much	4	I rather dislike it	7	I quite like it
2	I dislike it	5	I neither dislike it nor do I like it	8	I like it
3	I quite dislike it	6	I rather like it	9	I like it very much

B517 How high or low are the chances that you develop an illness when drinking water from the mitigation option?

Rather low		Rather average		Rather high	
1	Very low	4	Rather low	7	Quite high
2	Low	5	Average	8	High
3	Quite low	6	Rather high	9	Very high

B518 What do you think, how often do you need to drink arsenic-free water in order not experience any illness?

1	Arsenic is no health risk	2	I need to drink arsenic-free water once in a while	3	I mostly need to drink arsenic-free water	4	I always need to drink arsenic-free water

B519 Do you think that collecting water from mitigation option is time-consuming?

1	Not at all time-consuming	2	Not time-consuming	3	A little time-consuming	4	Time-consuming	5	Very time-consuming

B520 Do you think that collecting water from mitigation option is effortful?

1	Not at all effortful	2	Not effortful	3	A little effortful	4	Effortful	5	Very effortful

How effortful are the following characteristics of **collecting water from mitigation option**? How **often** they occur?

	_1 **How effortful is it?**					*_2* **How often does this happen?**				
	1 not effortful	**2 a little effortful**	**3 rather effortful**	**4 effortful**	**5 very effortful**	**1 almost never**	**2 seldom**	**3 some-times**	**4 often**	**5 almost always**
B521 Long distance	1	2	3	4	5	1	2	3	4	5
B522 Spending time	1	2	3	4	5	1	2	3	4	5
B523 Waiting time	1	2	3	4	5	1	2	3	4	5
B524 Physical: walking to well	1	2	3	4	5	1	2	3	4	5
B525 Physical: pumping the well	1	2	3	4	5	1	2	3	4	5
B526 Self willingness	1	2	3	4	5	1	2	3	4	5

	_1 **How effortful is it?**					_2 **How often does this happen?**				
B527 Keep in mind	1	2	3	4	5	1	2	3	4	5
B528 Be patient	1	2	3	4	5	1	2	3	4	5
	1 not effortful	**2 a little effortful**	**3 rather effortful**	**4 effortful**	**5 very effortful**	**1 almost never**	**2 seldom**	**3 some-times**	**4 often**	**5 almost always**
B529 Be punctual	1	2	3	4	5	1	2	3	4	5
B530 Planning to collect water	1	2	3	4	5	1	2	3	4	5
B531 Pay for using	1	2	3	4	5	1	2	3	4	5
B532 Share maintenance cost	1	2	3	4	5	1	2	3	4	5
B533 Maintain mitigation option	1	2	3	4	5	1	2	3	4	5
B534 Maintain good relationship with neighbor / owner / caretaker	1	2	3	4	5	1	2	3	4	5
B535 Other: ____________________	1	2	3	4	5	1	2	3	4	5

B536 How good or bad would you say is it to collect water from mitigation option?

Rather bad		Rather neutral		Rather good	
1	Very bad	4	A little bit bad	7	Quite good
2	Bad	5	Neither good nor bad	8	Good
3	Quite bad	6	A little good	9	Very good

B537 Considering all the benefits and efforts related to collecting your water from mitigation option, how much do you think is it worthwhile to collect your water from mitigation option?

Rather more effort than benefit		Rather neutral		Rather higher benefit than effort	
1	It costs much more effort than benefit	4	It costs slightly more effort than benefit	7	The benefit is quite higher than the effort
2	It costs more effort than benefit	5	The effort and the benefit are about the same	8	The benefit is higher than the effort
3	It costs quite more effort than benefit	6	The benefit is slightly higher than the effort	9	The benefit is very much higher than the effort

B538 How much do you like or dislike collecting water from mitigation option?

Rather dislike it		Rather neutral		Rather like it	
1	I dislike it very much	4	I rather dislike it	7	I quite like it
2	I dislike it	5	I neither dislike it nor do I like it	8	I like it
3	I quite dislike it	6	I rather like it	9	I like it very much

B539 How **proud or ashamed** are you to collect water from your neighbor's tubewell / the deep tubewell?

Rather ashamed		Rather neutral		Rather proud	
1	Very ashamed	4	Rather ashamed	7	Quite proud
2	ashamed	5	Neither ashamed nor proud	8	Proud
3	Quite ashamed	6	Rather proud	9	Very proud

B540 How **pleasant or unpleasant** is it for you fetch water from your neighbor's tubewell / the deep tubwell?

Rather pleasant		Rather neutral		Rather unpleasant	
1	Very unpleasant	4	rather unpleasant	7	quite plesant
2	unpleasant	5	neiter pleasant nor unpleasant	8	pleasant
3	quite unpleasant	6	rather pleasant	9	very pleasant

B541 How **positive or negative** do you think is it to collect from your neighbor's tubewell / the deep tubwell?

Rather negative		Rather neutral		Rather positive	
1	very negative	4	rather negative	7	quite positive
2	negative	5	neither negative nor positive	8	positive
3	quite negative	6	rather positive	9	very positive

B542 Do you think the caretaker/owner is capable or uncapable of taking care of the well?

Rather uncapable		Rather neutral		Rather capable	
1	very uncapable	4	rather uncapable	7	quite capable
2	uncapable	5	neither capable nor uncapable	8	capable
3	quite uncapable	6	rather capable	9	very capable
777	I dont know the caretaker / there is no caretaker				

B543 Do you think your neighbor whose tubewell you use / the caretaker is friendly or unfriendly?

Rather unfriendly		Rather neutral		Rather friendly	
1	very unfriendly	4	rather unfriendly	7	quite friendly
2	unfriendly	5	neutral	8	friendly
3	quite unfriendly	6	rather friendly	9	very friendly
777	I dont know the caretaker / there is no caretaker				

B544 Do you think your neighbor whose tubewell you use / the caretaker is trustworthy or untrustworthy?

Rather untrustworthy		Rather neutral		Rather trustworthy	
1	very untrustworthy	4	rather untrustworthy	7	quite trustworthy
2	untrustworthy	5	neutral	8	trustworthy
3	quite untrustworthy	6	rather trustworthy	9	very trustworthy
777	I dont know the caretaker / there is no caretaker				

B545 How much do you like or dislike the caretaker / neighbor whose tubewell you use?

Rather dislike him		Rather neutral		Rather like him	
1	I dislike him very much	4	I rather dislike him	7	I quite like him
2	I dislike him	5	I neither like nor dislike him	8	I like him
3	I quite dislike him	6	I rather like him	9	I like him very much
777	I dont know the caretaker / there is no caretaker				

B546 Does the mitigation option remove all harmful substances (e.g. iron, arsenic) / Is the water from mitigation option free from harmful substances?

1	2	3	4	5	6	888
No substances are removed	Rather few substances are removed	Some substances are removed	Quite a few substances are removed	Most substances are removed	All substances are removed	I do not know

B547 You collect water from the mitigation option. Do people who are important to you rather approve or disapprove of this? ***(for non-users: Suppose you drink water from the mitigation option)***.

Rather disapprove		Rather neutral		Rather approve	
1	Nearly all disapprove	4	Rather more disapprove	7	Sig. more approve
2	Most disapprove	5	Same amount disapprove and approve	8	Most approve
3	Significantly more disapprove	6	Rather more approve	9	Nearl all approve

B548 You DO NOT collect water from the mitigation option. Do people who are important to you rather approve or disapprove of this ***(for users: Suppose you stop driningk water from the mitigation option)***?

Rather disapprove		Rather neutral		Rather approve	
1	Nearly all disapprove	4	Rather more approve	7	Significantly more approve
2	Most disapprove	5	The same amount disapprove and approve	8	Most approve
3	Significantly more disapprove	6	Rather more approve	9	Nearly all approve

B549 Overall, how much would people who are important to you approve or disapprove that/if you collect water from mitigation option?

Rather disapprove		Rather neutral		Rather approve	
1	They would disapprove very much	4	They would rather disapprove	7	They would quite approve
2	They would disapprove	5	They would neither approve nor disapprove	8	They would approve
3	They would quite disapprove	6	They would rather approve	9	They would approve very much

B550 Overall, how much would people who are important to you approve or disapprove that/if you DO NOT drink water from the mitigation option?

Rather disapprove		Rather neutral		Rather approve	
1	They would disapprove very much	4	They would rather disapprove	7	They would quite approve
2	They would disapprove	5	They would neither approve nor disapprove	8	They would approve
3	They would quite disapprove	6	They would rather approve	9	They would approve very much

B551 Are there specific persons that are important to you, who would disapprove your collecting water from mitigation option?

1	No	2	Yes

B552 ***If yes:*** who? (specific persons that are important to you, who would disapprove your collecting water from mitigation option)

1	Local politicians	4	Elder/aged people	7	Illiterate people
2	Religious leader (eg imam)	5	Household head	8	Other:
3	Village leader	6	Caretaker	777	Not applicable

B553 In your opinion, what do these people dislike about you collecting water from the mitigation option?

1	They don't like me to go outside	4	They think it is too effortful	7	They think it's too expensive
2	They think the water tastes badly	5	They think it is shameful	8	They think the water quality is bad
3	They think it takes too much time	6	They don't want me to talk to the neighbor / caretaker	9	Other:
777	Not applicable				

B554 Are there specific persons that are important for you, who would approve of your collecting water from neighbor's tubewell / DTW?

1	No	2	Yes

B555 If yes, who? (persons who are important and who would approve that/if I collect water from neighbor / DTW)

1	Local politicians	4	Elder/aged people	7	Knowledgeable person
2	Religious leader (eg imam)	5	Household head	8	Health/NGO/Govt worker
3	Village leader	6	Caretaker	9	Other:
777	Not applicable				

B556 In your opinion, what do these people like about you collecting water from the mitigation option?

1	Arsenic-free water is important to them	4	They think it's healthy	7	Other:
2	Iron-free water is important to them	5	They like the temperature of the water	777	Not applicable
3	They like the taste of the water	6	They like the color of the water		

B557 What do you think, how much does the family, whose tubewell you use, like or dislike sharing it with you?

Rather dislike it		Rather neutral		Rather like it	
1	They dislike it very much	4	They rather dislike it	7	They quite like it
2	They dislike it	5	They neither dislike it nor do they like it	8	They like it
3	They quite dislike it	6	They rather like it	9	They like it very much

B558 To what extent do you see yourself as being capable of collecting water from mitigation option as often as you need?

1	2	3	4	5
Not at all capable	Not capable	Quite capable	Capable	Very capable

B559 In general, how difficult or easy is it to collect water from mitigation option?

Rather difficult		Rather neutral		Rather easy	
1	Very difficult	4	Rather difficult	7	Quite easy
2	Difficult	5	Neither easy nor difficult	8	Easy
3	Quite difficult	6	Rather easy	9	Very easy

B560 More specifically, how difficult or easy is it to find time to collect water from mitigation option?

Rather difficult		Rather neutral		Rather easy	
1	Very difficult	4	Rather difficult	7	Quite easy
2	Difficult	5	Neither easy nor difficult	8	Easy
3	Quite difficult	6	Rather easy	9	Very easy

B561 More specifically, how difficult or easy is it to get as much water as you need from mitigation option?

Rather difficult		Rather neutral		Rather easy
Very difficult	4	Rather difficult	7	Quite easy
Difficult	5	Neither easy nor difficult	8	Easy
Quite difficult	6	Rather easy	9	Very easy

B562 How many people of your atio shojun (= relatives), excluding people of your household collect water from mitigation option?

1	(Almost) nobody (0%)	2	Som of them (25%)	3	Half of them (50%)	4	Most of them (75%)	5	(Almost) all (100%)

B563 How many people outside your family collect water from mitigation option?

1	(Almost) nobody (0%)	2	Som of them (25%)	3	Half of them (50%)	4	Most of them (75%)	5	(Almost) all (100%)

B564 How certain are you that drinking only water from mitigation option prevents you from getting arsenicosis?

1	Not at all certain	2	Not very certain	3	Quite certain	4	Certain	5	Very certain

B565 How certain are you that cooking only with water from mitigation option prevents you from getting arsenicosis?

1	Not at all certain	2	Not very certain	3	Quite certain	4	Certain	5	Very certain

Willingness to pay

B800 How much did you pay for installation of the your neighbor's tubewell / the deep tubewell?

Taka:	888	Doesn’t own a tubewell.	9	I don't know

B801 How much do you pay per month for using your neighbor's tubewell / the deep tubewell / maintaining your tubewell?

Taka:	888	Doesn’t own a tubewell.	9	I don't know

B802 What would be the maximum amount you would be willing to pay for an arsenic test of your water source?_______ Taka

B803 Which price would you find reasonable to pay for an arsenic test of your water source? ___________Taka

B804 What do you think about the price of 100 Taka for an arsenic test of your water source?

1	very low price	2	low price	3	a modest price	4	high price	5	very high price

Health status and awareness

B805 How often do you talk about the mitigation option or arsenic free water?

1	2	3	4	5	6	7
never	less often than every month	every month	every 3 weeks	every 2 weeks	every week	every 1 to 3 days

B806 When you talk about the mitigation option and arsenic free water, do you talk positively or negatively about it?

Rather negatively		Rather neutrally		Rather positively	
1	very negatively	4	rather negatively	7	quite positively
2	negatively	5	neither negative nor positive	8	positively
3	quite negatively	6	rather positively	9	very positively

B807 How often do you talk positively about water treatment and health with others?

1	2	3	4	5	6	7
never	less often than every month	every month	every 3 weeks	every 2 weeks	every week	every 1 to 3 days

B808 Do you have arsenicosis?

1	No	2	Yes	9	I do not know

B809 How many people of your household have arsenicosis? ___________ people 888 ❑ I do not know

B810 How many people outside your family have arsenicosis? __________ people 888 ❑ I do not know

B811 Compared to persons your sex and age, how much higher or lower are your chances of developing arsenicosis?

1	2	3	4	5	6	7
Much lower	Lower	A little lower	About the same	A little higher	Higher	Very much higher

Imagine that you contracted arsenicosis, how severe would be the impact on your...

B812 ... life in general?

1	Not severe at all	2	Not severe	3	Quite severe	4	Severe	5	Very severe

B813 ... social life?

1	Not severe at all	2	Not severe	3	Quite severe	4	Severe	5	Very severe

B814 ... economic situation?

1	Not severe at all	2	Not severe	3	Quite severe	4	Severe	5	Very severe

B815 How high or low do you feel are the chances that you get arsenicosis?

Rather low		Rather average		Rather high	
1	Very low	4	Rather low	7	Quite high
2	Low	5	Average	8	High
3	Quite low	6	Rather high	9	Very high

B816 Why do you think that the chances that you develop arsenicosis are high/low/average?

1	drinking arsenic-free water	5	Drinking water from red tubewell	9	no problem found yet though drinking from a long period
2	drinking arsenic-contaminated water	6	Drinking red colored water	10	Other:
3	untested water	7	Drinking good or safe water	11	I don't know
4	drinking water from mitigation option	8	iron contaminated water		

B817 How high or low do you feel are the chances that you get arsenicosis if you only drink arsenic-free water?

Rather low		Rather average		Rather high	
1	Very low	4	Rather low	7	Quite high
2	Low	5	Average	8	High
3	Quite low	6	Rather high	9	Very high

B818 How high or low are the chances that someone of your family develops arsenicosis?

Rather low		Rather average		Rather high	
1	Very low	4	Rather low	7	Quite high
2	Low	5	Average	8	High

3	Quite low	6	Rather high	9	Very high

B819 Given that you don't have the possibility to have water from the mitigation option, what would you say is the likelihood that you would get arsenicosis?

1	very low	2	low	3	fifty-fifty	4	high	5	very high

B820 How high or low do you feel are the chances that you get arsenicosis if you **DO NOT** drink arsenic-free water?

Rather low		Rather average		Rather high	
1	Very low	4	Rather low	7	Quite high
2	Low	5	Average	8	High
3	Quite low	6	Rather high	9	Very high

B821 Which water sources do you know that are free from arsenic? ***(Don't read this list! Multiple choice)***

1	Respondent doesn't know any	5	Sidko plant	8	Rainwater harvesting
2	Green tubewell	6	Household filter (SONO, Alcan, Read-F)	9	Piped water supply
3	Deep tubewell			10	Pond / river water (untreated)
4	Pond sand filter	7	Dug well	11	Other

Arsenic knowledge quiz

The questions and responses will be read to the study participant. The interviewer should circle the number corresponding to the subject's answer. Tell other individuals present during the quiz to not assist the respondent. Remind respondents that it is okay if they don't know an answer. However do not suggest that a respondent answer "I don't know" to any particular study question.

PLEASE ASK IF ANY STUDY RESPONDENTS ARE PRESENT. IF SO PLEASE ASK THEM TO LEAVE DURING THE QUIZ. .THEY CANNOT BE PRESENT.

GIVE RESPONDENTS TIME TO THINK ABOUT THE QUESTIONS

B822 Do you know where an arsenic-safe drinking water source is located in your village?

1	No	2	Yes	9	I don't know

B823 How many minutes is the closest arsenic safe drinking water source to your home (1 way)

1	2	3	4	5	888
1 Minute or less	> 1 min to 5 min	> 5 min to 10 min	> 10 min to 20 min	> 20 min	I don't know

B824 Which water source is that? (don't read this list! Only 1 answer!)

1	Green shallow tubewell	5	Household filter (SONO, Alcan, Read-F)	9	Pond / river water (untreated)
2	Deep tubewell	6	Dug well	10	Red shallow tubewell
3	Pond sand filter	7	Rainwater harvesting	11	Untested shallow tubewell
4	Sidko plant	8	Piped water supply	12	Other:

B825 Where is arsenic contaminated water mainly found?

1	Pond water	4	Dug well	7	None of these
2	River water	5	Canal	99	Do not know
3	Tube well water	6	Rainwater	88	Refuse to answer

B826 What is the Bangladesh standard to define safe level of arsenic in drinking water?

1	2	3	4	9	888
Less than 100	Less than 70	Less than 50	Less than 10	Do not know	Refuse to answer

B827	Is it safe to drink from a green color tubewell?	1☐ No	2☐ Yes	9☐ Do not know	888☐Refuse to answer
B828	Is it safe to drink from a red color tubewell?	1☐ No	2☐ Yes	9☐ Do not know	888☐Refuse to answer

I am going to read a list of medical conditions. Please tell me if arsenic exposure can cause these conditions.

B829 Cancer	1	Yes	2	No	9	I don't know	888	refuse to answer
B830 Cholera	1	Yes	2	No	9	I don't know	888	refuse to answer
B831 Skin diseases	1	Yes	2	No	9	I don't know	888	refuse to answer
B832 Diarrhea	1	Yes	2	No	9	I don't know	888	refuse to answer
B833 Vomit	1	Yes	2	No	9	I don't know	888	refuse to answer

B834 Can eating or sleeping with an arsenicosis patient cause the transmission of this disease?	1	Yes	2	No	9	I don't know	888	refuse to answer
B835 Can arsenic be removed by boiling water?	1	Yes	2	No	9	I don't know	888	refuse to answer

I am going to read a list of common tasks we do each day. For each task, tell me whether or not it is okay to use arsenic contaminated water.

B836 Drinking	1	Yes	2	No	9	I don't know	888	refuse to answer
B837 Cooking	1	Yes	2	No	9	I don't know	888	refuse to answer
B838 Washing hands	1	Yes	2	No	9	I don't know	888	refuse to answer
B839 Bathing	1	Yes	2	No	9	I don't know	888	refuse to answer
B840 Washing clothes	1	Yes	2	No	9	I don't know	888	refuse to answer
B841 Bathing the animals								

B842 Are you currently involved in arsenic intervention or trial?

1	No	2	Yes

B843 If "yes": please explain (what kind of intervention or trial)

………

………

Media Access

B844 Do you own a radio or have access to one?

1	No	2	Yes

B845 Do you own a TV or have access to one?

1	No	2	Yes

Media	_1 **How often do you listen / watch / pay attention?**		_2 **How important is it what you hear?**		_3 **How much do you believe in what they say?**	
B846 Radio	1 2 3 4 5	Never Every month Every two weeks Every week Every day	1 2 3 4 5	Not at all important Not important A little bit important Important Very important	1 2 3 4 5	I don't believ it at all I believe little I believe some I believe much I blieve (almost) all
B847 TV	1 2 3 4 5	Never Every month Every two weeks Every week Every day	1 2 3 4 5	Not at all important Not important A little bit important Important Very important	1 2 3 4 5	I don't believ it at all I believe little I believe some I believe much I blieve (almost) all
B848 Micro message (e.g. Riksha, Mosque, CNG)	1 2 3 4 5	Never Every month Every two weeks Every week Every day	1 2 3 4 5	Not at all important Not important A little bit important Important Very important	1 2 3 4 5	I don't believ it at all I believe little I believe some I believe much I blieve (almost) all

B849 Which media do you prefer?

1	Radio	4	Theatre	7	Other:
2	TV	5	Leaflet		
3	Micro message	6	Poster / banner		

Sociodemographic Information

B900 Gender

1	Male	1	Female

B901 Age........................... Years

B902 Occupation (Respondent)

1	Agriculture (owner)	6	Large business (e.g. big shop)	11	Student
2	Agricultural labor	7	Small business (e.g. tea stall)	12	Retired
3	Labour (non-agricultural)	8	Formal employment	13	Unemployed
4	Rickshaw/van puller	9	Informal employment	14	Other:
5	Driver (CNG, car, bus)	10	Housewife		

B903 Occupation (Head of household)

1	Agriculture (owner)	6	Large business (e.g. big shop)	11	Student
2	Agricultural labor	7	Small business (e.g. tea stall)	12	Retired
3	Labour (non-agricultural)	8	Formal employment	13	Unemployed
4	Rickshaw/van puller	9	Informal employment	14	Other:
5	Driver (CNG, car, bus)	10	Housewife		

B904 Are you able to read or write?

1	Can neither read nor write	2	Can read only	3	Can both read and write

B905 Education (years)........................... years

B906 Religion

1	Muslim	2	Hindu	3	Bhuddist	4	Christian

B907 Total number of persons living in the household incl. Children (total) ....

B908 How many rooms does your household have? ....

B909 Monthly expenditure......................................Taka 9 ❑ I don't know

B910 Monthly income..................................... Taka 9 ❑ I don't know

B911 How much land does your household own (including homestead land)?

B912 Do you have

1	No	2	Yes

electricity?

B913 Name:..Nick name:...

B914 Detail address:

Father/husband name:.. Nick name...

Bari (house) name: .... Para name: ....

Village name: .... Post office: ....

Upazila: .... District: ....

B915 Mobile number (where interviewed person can be reached):

9 ❑ Not interested to give phone number

B916 Time of day that is best to reach the respondent: ....:.......... am / pm

Do you have any comments?

....
....
....

B917 Number of people present during the interview: …………… Person End time: ....

For Official use:

Checked: ❑ yes Initials: .... **Data entered:** ❑ yes Initials: ……..

Appendix II: Supplementary information Chapter III

Supplementary information Chapter III

Predicting Water-Consumption Habits for Seven Arsenic-Safe Water Options in Bangladesh

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Number of tables: 2

Total number of pages SI: 6

Table S-1. Definition and Operationalization of Constructs

Construct	Definition	Items	Answering options	Cronbach's Alpha
Habitual behavior	A continuum expressing the combination of a person's current arsenic-safe water consumption, as well as its automaticity and regularity. It reaches from not performing a behavior with zero habit strength (i.e. no prior experience of performing it) to an always performed behavior with great habit strength.	Averaged sum scale of current arsenic-safe water consumption, perceived habit, automaticity and regularity.	0 = not currently consuming arsenic-safe water and no habit to 4 = currently consuming arsenic-safe water with maximum habit strength	0.908
		Current arsenic-safe water consumption: 1. How many vessels of drinking water do you collect from … (arsenic-contaminated shallow tubewell; arsenic-safe shallow tubewell; deep tubewell; pond sand filter; dug well; household arsenic removal filter; community arsenic removal filter; piped water supply; pond; river; other; in total)?	Number of vessels	
		2. Calculate proportion of arsenic-safe drinking water of total drinking water consumption.	0 = drinks no arsenic-safe water (0%) to 4 = drinks only arsenic-safe water (100%)	
		Perceived habit: Filling the filter with water / collecting water from the arsenic-safe water option is something I do as a matter of habit.	0 = I strongly disagree to 4 = I strongly agree	
		Automaticity: Do you go to collect water from arsenic-safe option automatically?	0 = not at all automatically to 4 = very automatically	
		Regularity: (Preceding open question: When do you usually go to collect water from the arsenic-safe water option?). How often do you go to collect water from the arsenic-safe option at these moments?	0 = almost never to 4 = almost always	
Severity	Perception concerning the seriousness of the consequences of contracting an illness (Brewer et al., 2007; Floyd et al., 2000).	Imagine that you contracted arsenicosis, how severe would be the impact on your life in general?	0 = not at all severe to 4 = very severe	0.951
		Imagine that you contracted arsenicosis, how severe would be the impact on your social life?	0 = not at all severe to 4 = very severe	
		Imagine that you contracted arsenicosis, how severe would be the impact on your economic situation?	0 = not at all severe to 4 = very severe	
Vulnerability	Perception of personal risk of contracting a particular illness (Brewer et al., 2007; Floyd et al., 2000).	How high or low do you feel are the chances that you get arsenicosis?	- 4 = very low to 4 = very high	0.958
		How high or low are the chances that someone of your family develops arsenicosis?	- 4 = very low to 4 = very high	

Table S-1. Definition and Operationalization of Constructs (continued)

Construct	Definition	Items	Answering options	Cronbach's Alpha
Affective attitude arsenic-safe option (contaminated or untested tubewell)	Feelings that arise when performing a behavior or thinking about it (Trafimow & Sheeran, 1998).	How much do you like or dislike drinking water from the arsenic-safe option (contaminated or untested tubewell)?	- 4 = I dislike it very much to 4 = I like it very much	0.929 (0.888)
		How much do you like or dislike the taste of water from the arsenic-safe option (contaminated or untested tubewell)?	- 4 = I dislike it very much to 4 = I like it very much	
		How much do you like or dislike the smell of water from the arsenic-safe option (contaminated or untested tubewell)?	- 4 = I dislike it very much to 4 = I like it very much	
		How much do you like or dislike the temperature of water from the arsenic-safe option (contaminated or untested tubewell)?	- 4 = I dislike it very much to 4 = I like it very much	
		How much do you like or dislike the color of water from the arsenic-safe option (contaminated or untested tubewell)?	- 4 = I dislike it very much to 4 = I like it very much	
Instrumental attitude arsenic-safe option	Beliefs about the benefits and costs of a behavior (Trafimow & Sheeran, 1998).	Do you think that using the filter / collecting water from the arsenic-safe option is time-consuming?	0 = not at all time-consuming to 4 = very time-consuming	0.672
		Do you think that using the filter / collecting water from the arsenic-safe option is effortful?	0 = not at all effortful to 4 = very effortful	
		What are the advantages of drinking water from arsenic-contaminated or untested tubewell?	Number of advantages of arsenic-contaminated wells	
		What are the disadvantages of drinking water from arsenic-safe option?	Number of disadvantages of arsenic-safe water options	
Injunctive norm arsenic-safe option	Perceptions about which behaviors are typically approved ore disapproved (Schultz et al., 2007)	How good or bad would you say is it to drink water from the arsenic-safe option?	- 4 = very bad to 4 = very good	0.801
		How proud or ashamed are you to offer water from the arsenic-safe option to your guests?	-4 = very ashamed to 4 = very proud	
		What do you think of people who use arsenic-safe options?	-4 = I think very badly of them to 4 = I think very well of them	

Note. Cronbach's Alphas in parentheses are for the constructs referring to the contaminated tubewell.

Table S-1. Definition and Operationalization of Constructs (continued)

Construct	Definition	Items	Answering options	Cronbach's Alpha
Descriptive norm arsenic-safe option (contaminated or untested tubewell)	Perceptions about which behaviors are typically performed (Cialdini, 2003)	How many people of your relatives, excl. people of your household, drink water from the arsenic-safe option (the contaminated or untested tubewell)?	0 = (almost) nobody to 4 = (almost) all of them	0.588 (0.666)
		How many people outside your family drink water from the arsenic-safe option (the contaminated or untested tubewell)?	0 = (almost) nobody to 4 = (almost) all of them	

Note. Cronbach's Alphas in parentheses are for the constructs referring to the contaminated tubewell.

Construct	Definition	Items	Answering options	Cronbach's Alpha
Self-efficacy arsenic-safe option	The belief in one's capabilities to organize and execute the courses of action required to manage prospective situations (Bandura, 1997)	Are you sure that you can use the filter to prepare / that you can collect as much arsenic-safe water as you need within the next year?	0 = not at all sure to 4 = very sure	0.914
		Are you sure that you can use the filter to prepare / that you can collect as much arsenic-safe water as you need within the next month?	0 = not at all sure to 4 = very sure	
		Are you sure that you can use the filter to prepare / that you can collect as much arsenic-safe water as you need within the next week?	0 = not at all sure to 4 = very sure	
Coping planning	The presumption of possible barriers and the invention of ways to overcoming them (Schwarzer, 2008)	Have you made a detailed plan regarding what to do when the arsenic-safe option gets broken?	0 = no detailed plan at all to 4 = very detailed plan	0.924
		Have you made a detailed plan regarding how to avoid forgetting to fill the filter / to collect water from the arsenic-safe option?	0 = no detailed plan at all to 4 = very detailed plan	

Note. Cronbach's Alphas in parentheses are for the constructs referring to the contaminated tubewell.

Analysis of the Estimated Parameter Values

In the paper, the generalizability of the model was only tested based on the fitting abilities (i.e., by comparing the R-squares). However, besides the general information of how well other behaviors can be explained, by using a number of different datasets that all refer to different behaviors, it can also be estimated how much the estimated parameter values vary. Thus, similarly to the confidence estimates for sampling effects, we get indicators for the uncertainty when applying the model to other behaviors.

The parameter values and their confidence intervals are shown in Table S-3. The estimates with data of one behavior missing show a very small variability of the parameter estimates. The absolute differences to the reference estimates (Estimate 1) and their confidence intervals are mostly smaller than 0.05. Only the constants (between –0.38 and +0.45) and, for Estimate 2, the descriptive norm arsenic-safe option (–0.12), show absolute deviations larger than 0.1 from the reference estimates. Compared to the uncertainty due to sampling, which in most cases is more than double in size, the error of applying the estimated parameter values to other behaviors seems of little importance. In fact, only the estimates of the instrumental attitude arsenic-safe option and the descriptive norm arsenic-safe option of Estimate 2, have values outside the 95% confidence bounds of the reference estimates. Thus, the differences of the parameter estimates might be explained by random differences of the samples and not by differences in the explained behaviors.

In the worst-case scenario of having estimated the parameters with rather similar data for a forecast of quite different behaviors (Estimates 9 and 10), the parameter estimates still differ little from the reference estimates. In Estimate 9, only the estimates for the constant (+0.45) and the instrumental attitude arsenic-safe option (–0.11), and in Estimate 10, the estimates for the constant (–0.23) and the descriptive norm arsenic-safe option (–0.11), deviate more than ±0.1 from the reference estimates. Besides the parameter estimates for these variables, the estimate for the self-efficacy arsenic-safe option of Estimate 9 and, for Estimate 10, the estimates for the instrumental attitude arsenic-safe option and the self-efficacy arsenic-safe option are outside the 95% confidence interval of the reference parameter estimates. This indicates the necessity for further investigations of psychological differences and similarities of different options for mitigating the problem of arsenic in drinking water.

To conclude, regarding the variability of the parameter estimates, the model generalizes well. The differences of the parameter values can mostly be explained by differences in the samples. Nevertheless, further analyses of the differences of the behaviors might be valuable.

Table S-2: Estimated parameter values (B) and 95% confidence intervals for different sub-samples

	Estimate									
Variables in the equation	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Parameter estimates										
(Constant)	-0.54	-0.80	-0.42	-0.41	-0.29	-0.54	-0.36	-0.92	-0.08	-0.77
Severity	0.00	0.04	-0.01	-0.04	0.00	0.01	-0.06	0.05	-0.04	0.05
Vulnerability	-0.20	-0.21	-0.18	-0.20	-0.21	-0.19	-0.18	-0.20	-0.22	-0.19
Affective attitude arsenic-safe option	0.00	0.01	0.00	0.02	0.01	0.02	0.00	-0.03	0.04	0.01
Instrumental attitude arsenic-safe option	0.24	0.34	0.22	0.20	0.19	0.21	0.24	0.28	0.12	0.33
Affective attitude contaminated/untested tubewell	-0.04	-0.05	-0.06	-0.03	-0.03	-0.04	-0.03	-0.03	-0.03	-0.07
Injunctive norm arsenic-safe option	0.08	0.04	0.06	0.09	0.09	0.05	0.09	0.12	0.11	0.02
Descriptive norm arsenic-safe option	0.34	0.22	0.37	0.35	0.34	0.35	0.37	0.33	0.35	0.22
Descriptive norm contaminated/untested tubewell	-0.02	-0.02	-0.05	-0.01	-0.02	-0.02	-0.02	-0.03	0.00	-0.04
Self-efficacy arsenic-safe option	0.42	0.49	0.42	0.41	0.36	0.44	0.41	0.41	0.32	0.50
Coping planning	0.03	0.02	0.02	0.01	0.03	0.03	0.02	0.06	0.02	0.04
Upper limit of 95% confidence interval of parameter estimates										
(Constant)	-0.15	-0.41	0.01	0.00	0.11	-0.12	0.06	-0.51	0.35	-0.31
Severity	0.09	0.14	0.09	0.06	0.10	0.11	0.04	0.15	0.07	0.15
Vulnerability	-0.17	-0.18	-0.14	-0.17	-0.18	-0.16	-0.15	-0.17	-0.19	-0.16
Affective attitude arsenic-safe option	0.05	0.06	0.05	0.08	0.06	0.07	0.05	0.02	0.11	0.06
Instrumental attitude arsenic-safe option	0.31	0.42	0.31	0.28	0.27	0.29	0.32	0.35	0.22	0.42
Affective attitude contaminated/untested tubewell	-0.01	-0.02	-0.02	0.00	0.00	0.00	0.01	0.01	0.01	-0.03
Injunctive norm arsenic-safe option	0.15	0.12	0.14	0.17	0.17	0.13	0.17	0.20	0.20	0.11
Descriptive norm arsenic-safe option	0.40	0.29	0.45	0.42	0.41	0.42	0.43	0.39	0.42	0.31
Descriptive norm contaminated/untested tubewell	0.06	0.06	0.03	0.08	0.06	0.07	0.07	0.06	0.09	0.05
Self-efficacy arsenic-safe option	0.49	0.56	0.49	0.48	0.44	0.51	0.48	0.48	0.41	0.58
Coping planning	0.09	0.08	0.09	0.08	0.09	0.10	0.08	0.12	0.09	0.11

Table S-2: Estimated parameter values (B) and 95% confidence intervals for different sub-samples (continued)

	Estimate									
Variables in the equation	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Lower limit of 95% confidence interval of parameter estimates										
(Constant)	-0.92	-1.20	-0.85	-0.82	-0.69	-0.97	-0.77	-1.33	-0.52	-1.22
Severity	-0.09	-0.05	-0.11	-0.14	-0.10	-0.09	-0.16	-0.05	-0.15	-0.06
Vulnerability	-0.23	-0.24	-0.21	-0.23	-0.24	-0.23	-0.21	-0.23	-0.25	-0.22
Affective attitude arsenic-safe option	-0.05	-0.04	-0.05	-0.04	-0.04	-0.03	-0.06	-0.08	-0.02	-0.05
Instrumental attitude arsenic-safe option	0.16	0.26	0.14	0.11	0.11	0.12	0.16	0.20	0.03	0.25
Affective attitude contaminated/untested tubewell	-0.07	-0.08	-0.09	-0.07	-0.07	-0.07	-0.07	-0.06	-0.07	-0.10
Injunctive norm arsenic-safe option	0.00	-0.04	-0.03	0.01	0.00	-0.03	0.01	0.04	0.02	-0.06
Descriptive norm arsenic-safe option	0.27	0.15	0.30	0.28	0.27	0.28	0.30	0.26	0.27	0.14
Descriptive norm contaminated/untested tubewell	-0.10	-0.09	-0.14	-0.09	-0.10	-0.10	-0.10	-0.11	-0.09	-0.12
Self-efficacy arsenic-safe option	0.36	0.43	0.35	0.34	0.29	0.37	0.34	0.34	0.24	0.43
Coping planning	-0.03	-0.04	-0.05	-0.06	-0.04	-0.03	-0.04	-0.01	-0.06	-0.03
R^2	0.69	0.72	0.68	0.68	0.66	0.67	0.69	0.71	0.66	0.73
n	867	745	741	742	745	742	745	742	620	619

Note. Dependent: habitual use of arsenic-safe drinking water options. Samples in the Estimates: Estimate 1 = all; Estimate 2 = all excl. rainwater harvesting; Estimate 3 = all excl. household arsenic removal; Estimate 4 = all excl. community arsenic removal; Estimate 5 = all excl. pond sand filter; Estimate 6 = all excl. piped water supply; Estimate 7 = all excl. dug well; Estimate 8 = all excl. well-switching; Estimate 9 = all excl community arsenic removal and pond sand filter; Estimate 10 = all excl. rainwater harvesting, and household arsenic removal.

Appendix III: Intervention materials

Information intervention

Information on arsenic, arsenicosis and arsenic-safe water options

1

Explanation for **Page 1**:

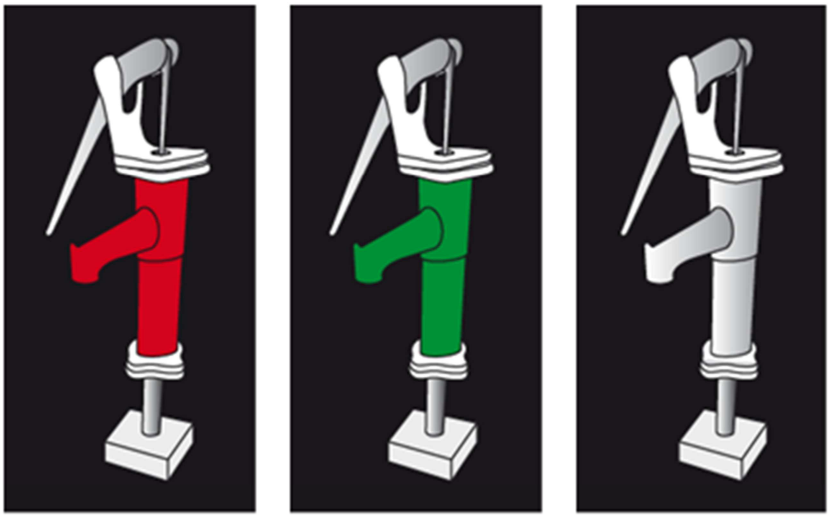
Promoter, please explain the following to the participant when showing page 1 of this booklet

- Arsenic is a chemical found in some tubewells in your area.
- This poses a potential threat to your health and to the health of your children.
- Today, I would like to inform you about arsenic, its health effects and how you can avoid these health effects.
- Please ask me any questions you may have during and after this session.

E1

Information intervention

Arsenic contaminated, arsenic-safe and untested tubewells



2

Explanation for **Page 2**:

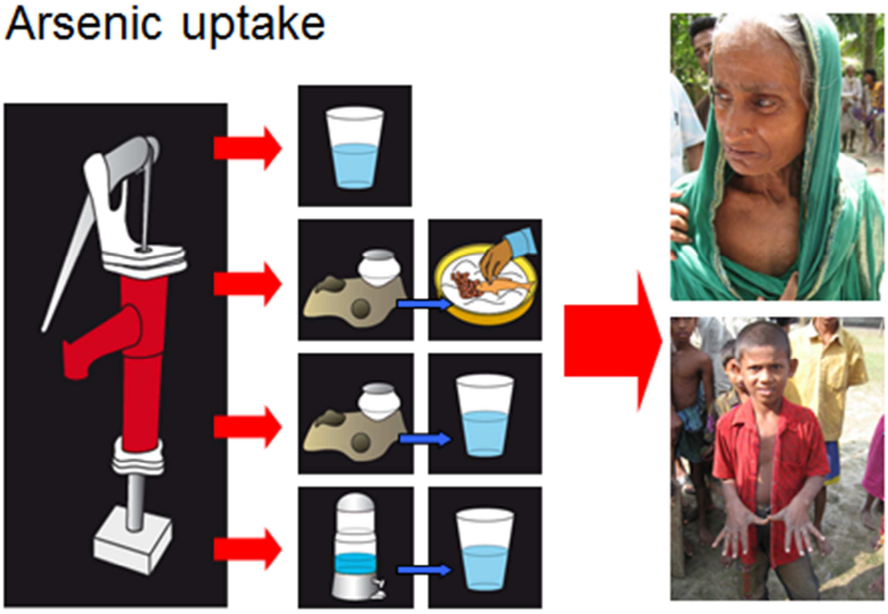
Promoter, please explain the following to the participant when showing page 2 of this booklet

- In Bangladesh, arsenic occurs in shallow groundwater.
- Arsenic is a poisonous chemical that is endangering human health.
- Arsenic is not visible, it is transparent. It has neither taste nor smell.
- In your area, some of the shallow tubewells are contaminated with arsenic, and some of the tubewells are free from arsenic.
- Tubewells that have been tested for arsenic and found contaminated are sometimes painted red.
- Tubewells that have been tested for arsenic and found arsenic-free are sometimes painted green.
- Tubewells that are without coloring: These are either untested or the colors have worn off. It is not sure whether they are contaminated with arsenic or not.

E2

Information intervention

Arsenic uptake



3

Explanation for **Page 3**:

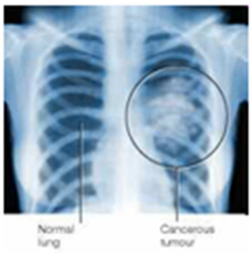
Promoter, please explain the following to the participant when showing page 3 of this booklet

- Arsenic enters the human body in the following ways:
  1. Arsenic can enter the body by drinking water from contaminated tubewells (= red tubewells).
  2. Arsenic can enter the body by eating food that was cooked with arsenic-contaminated water.
  3. Arsenic can not be removed by boiling: Arsenic can enter the body by drinking pre-boiled arsenic-contaminated water.
  4. Arsenic can not be removed by common household filters: Arsenic can enter the body by drinking arsenic-contaminated water that was filtered with common household filters.
- If arsenic-contaminated water is consumed, severe health effects may occur to you and your family members, including your children.
- Note that you do not know whether untested tubewells are contaminated or not. They are therefore not safe to use.

E3

Information intervention

Health effects: Arsenicosis



4

Explanation for **Page 4**:

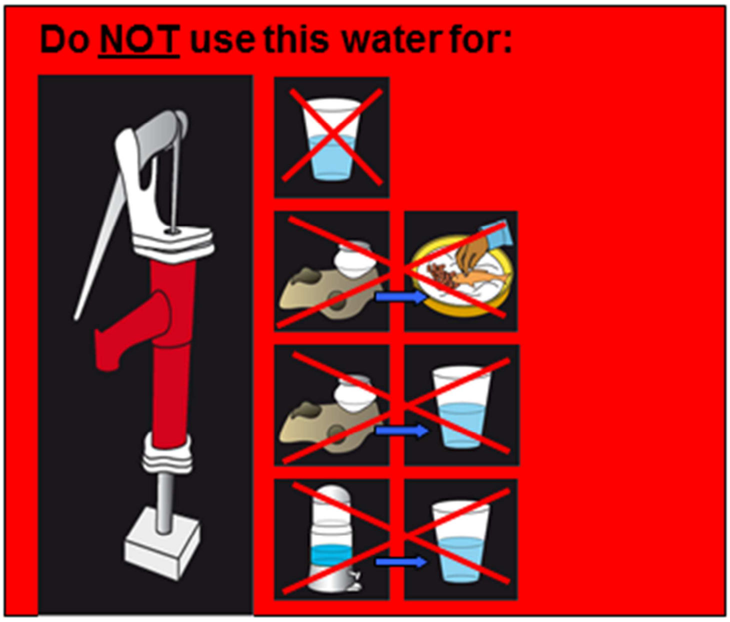
Promoter, please explain the following to the participant when showing page 4 of this booklet

- The disease developed by chronic consumption of arsenic is named "arsenicosis".
- Arsenicosis develops over a period of several years when drinking or cooking with water from contaminated tubewells
- It may be that you do not notice any health effects for a long period, although arsenic is slowly affecting your body.
- There are several symptoms of arsenicosis. Some are visible on your body, some are invisible.
- The symptoms include:
  - Skin diseases: dark spots and white spots on the skin, hardening of the skin.
  - Cardiovascular diseases (e.g. heart problems)
  - Gangrene
  - Problems with children's brain development
  - Cancers of skin, lung, kidney and bladder
- Ultimately, arsenicosis may end in death
- Unfortunately, there is no cure for arsenicosis. However, I will explain to you now, how you can avoid developing this disease.

E4

Information intervention

How to prevent arsenicosis



5

Explanation for **Page 5**:

Promoter, please explain the following to the participant when showing page 5 of this booklet

- To avoid developing arsenicosis and prevent you and your family from suffering its health effects, stop using water from contaminated or untested tubewells for drinking or cooking.
- Do not drink the water from untested or contaminated tubewells!
- Do not eat food that was cooked with water from untested or contaminated tubewells!
- Do not drink pre-boiled water from untested or contaminated tubewells!
- Do not drink contaminated or untested water that was filtered with common household filters!

E5

Information intervention

Tubewells that are safe for drinking

Arsenic-safe shallow tubewell

(sometimes painted green)

Deep tubewell

- *Usually used by the community*
- *Somebody is appointed caretaker*

6

Explanation for **Page 6**:

Promoter, please explain the following to the participant when showing page 6 of this booklet

- In the following, I would like to talk to you about water sources that are safe from arsenic.
- You can use these water sources for drinking and for cooking.
- Arsenic-safe tubewells:
  1. In your neighborhood, some shallow tubewells are free from arsenic. You can recognize them by their green color.
  2. In your village, some tubewells are deep tubewells. They are installed for community use and usually have a caretaker. These are free from arsenic because they are go to deeper groundwater that is free from arsenic.

E6

Information intervention

Other arsenic-safe water sources

Arsenic removal:

Household filters (SONO, Alcan, Read-F) and

Sidko community filter

Pond sand filter

Dug well

Rainwater harvesting

Piped water supply

7

Explanation for **Page 7**:

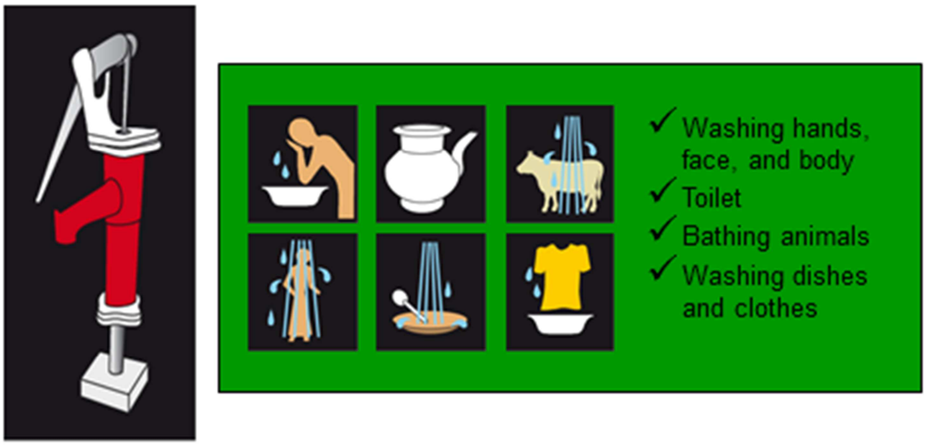
Promoter, please explain the following to the participant when showing page 7 of this booklet

- Besides arsenic-safe tubewells, there are other ways to get safe water:
  - **Arsenic-removal filters**: These are special filters that can remove arsenic.
    - There are three household filters: SONO, Alcan, Read-F.
    - Community plant: Sidko.
  - **Pond sand filter**: Pond water is arsenic free. To remove health-hazardous bacteria, pond water is filtered by a big sand filter system.
  - **Dug well**: Hand dug wells are free from arsenic. However, it may contain bacteria. Therefore it is advisable to boil before drinking.
  - **Rainwater harvesting**: Rainwater is arsenic-free. It can be collected and stored in a tank.
  - **Piped water supply**: These systems also use arsenic-free water.

E7

Information intervention

You CAN use this water for:



8

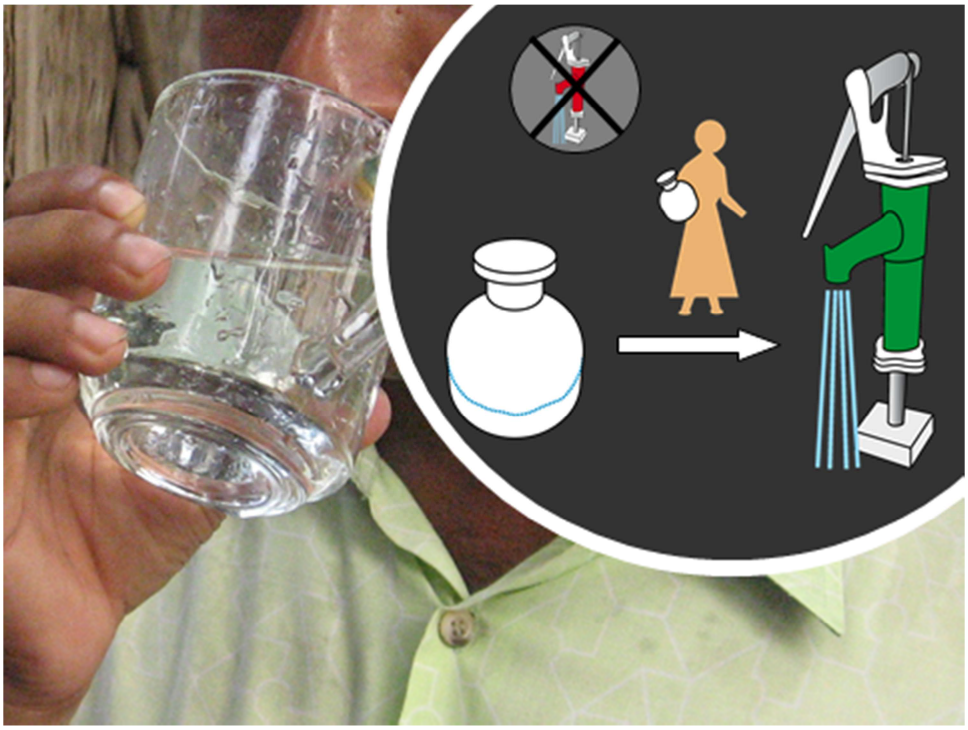
Explanation for **Page 8**:

Promoter, please explain the following to the participant when showing page 8 of this booklet

- Finally, I would like to point out some activities that you can use the water from the arsenic-contaminated tubewell for:
  - Washing hands, face and body
  - Toilet purposes
  - Bathing your animals
  - Washing dishes
  - Washing clothes

E8

Information intervention



Explanation for **Page 9**:

Promoter, please explain the following to the participant when showing page 9 of this booklet

- **To summarize:**
  - Arsenic-contaminated water is found in red tubewells and may be found in untested tubewells.
  - Drinking and/or cooking with arsenic-contaminated water is dangerous to your health and the health of your family.
  - To avoid arsenicosis, do not drink or cook with arsenic contaminated water.
  - Go collect water at an arsenic-safe water source, e.g. a neighbor's arsenic-safe tubewell or a deep tubewell.

- **Thank you for listening! I will be happy to answer any of your questions.**

E9

Reminders

1. Prompt:

2. Tag on contaminated well:

Implementation intention

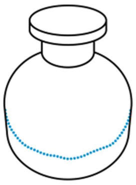
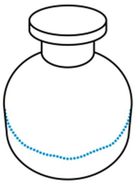
Filled-in example:

Commitment contract of *Amena* **(Participant name)**

Every day after / before 
(getting up / breakfast /.....)

and after / before  and after / before 

I am going to walk to *Mubarok*'s tubewell
(name of green tubewell owner)

and I am going to collect  
(number of kolshi)

for  and ".
(drinking / cooking / drinking and cooking)

Signature

Public commitment

Instructions for promoters

Description
The public commitment is a meeting that we will hold with our participants of each village that was assigned this intervention. At these meetings, we will conduct an information session with posters, as well as a public commitment. For the public commitment, every one of the participants will be asked to put up their hands if they commit to collecting only arsenic-safe water for drinking and/or cooking. Participants who are committed are then asked to get up and tell their implementation intention aloud to the community.

Note that participants were prepared for and invited to the meetings by the promoters. Promoters have informed participants of the date and time of the meeting and have asked them to bring the implementation intention to the meeting (they filled this in during the promoter household visit).

Staff requirement
- 2 promoters
- 1 field supervisor

Materials
- 8 community meeting posters on arsenic, arsenicosis, and arsenic-safe water sources
- Public commitment report sheet
- Address list
- Photo camera / video camera
- Tea and biscuits

Tasks for the supervisor:
- Fill in public commitment report sheet.
- Tape the whole community meeting by video.
- Take pictures during the meeting.
- Supervise the meeting and assist promoters where necessary.

Duration

- App. 1.5 - 2 hours (depending on group size)
- Try to stay within this time frame!

Procedure

1. All participants gather at the location of the meeting. These will be approximately 20-30 people, depending on the village. Ask the people to sit in a circle, so everybody can see you.

2. Request all people to identify themselves:
   a) Mark present participants on your public commitment report sheet.
   b) Try to contact missing participants by mobile phone and ask them to join.
   c) Kindly ask people who are not our study participants to leave (except children), especially the participants' husbands.
   d) Check whether participants brought their implementation intention contracts. If they haven't got it with them, ask them to go back home to bring it, if possible. If not possible (e.g. because too far), ask them to try to remember their implementation intention.

3. Introduction: Welcome all participants to the meeting, thank them for coming and introduce yourselves as promoters of CCDB / Eawag.

4. **Information session on arsenic, arsenicosis and arsenic-safe water sources:**
   a) Duration: app. 30 minutes.
   b) Conduct the information session by means of the posters.
   c) One of you will walk around the circle of people and demonstrate the posters while the other one of you is explaining.
   d) Important: Make sure that all participants can clearly hear you and see the posters!
   e) Answer remaining questions of participants regarding arsenic, arsenicosis or arsenic-safe water options.

5. **Public commitment:**
   a) Duration: app. 45 minutes.
   b) Ask the group of participants to now commit themselves **to only collect drinking water from their neighbors' arsenic-free tubewell (Shivalaya) / water from the deep tubewell (Monoharganj)**.
   c) Request the people who commit themselves to clearly raise their hands.
   d) Mark for each participant, whether they publicly committed themselves or not on the public commitment report sheet.
   e) Ask each committed participant to **read/tell their implementation intention** aloud to the group: when, where, how much water, for which purpose they are going to collect water from now on.

6. Offer tea and biscuits to all participants.

7. Closing: Thank all participants for coming and committing themselves and close the meeting.

Curriculum vitae

Jennifer Inauen

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EDUCATION

Feb 2009 – Sep 2012	Eawag, the Swiss Federal Institute of Aquatic Science & Technology, and the University of Zurich, Switzerland *PhD studies*
Aug 2011	Swiss Summer School, Lugano, Switzerland Course: Applied Analysis of Variance and Linear Modeling
Sep 2009	CREATE Workshop, Pisa, Italy Course: Advancing the science of behavior change: Methods and theories
Aug 2009	ECPR Summer School in Methods and Techniques, Ljubljana, Slovenia Course: Confirmatory factor analysis and structural equation modeling
Oct 2002 to Apr 2008	Studies in Psychology, Psychopathology and Criminology, University of Zurich, Switzerland Degree: Master of Science Thesis title: How prompts and public commitment affect the use of solar water disinfection: A time series analysis

ACADEMIC WORK EXPERIENCE

April 2012 to present	University of Konstanz, Department of Psychology, Developmental and Health Psychology (Prof. Dr. Urte Scholz) *Research Associate*
May 2008 to March 2012	Eawag, the Swiss Federal Institute of Aquatic Science & Technology, Dübendorf *Research Associate*

ACADEMIC AWARDS

2010	Travel award of the 11th Swiss Global Change Day for best poster (IHDP)

PROJECTS

2010 - 2011 **Revamping communication strategy and materials for arsenic mitigation through identifying behavior influencing key factors**
Consultancy for UNICEF Bangladesh to improve national communication strategy to mitigate arsenic contamination. Design, implementation, and evaluation of interventions aimed at increasing arsenic-safe water consumption.

2009 - 2011 **Analysis of the acceptance and use of arsenic mitigation options and evaluation of successful promotion strategies in Bangladesh**
Design, implementation, and evaluation of interventions to enhance the development of arsenic-safe water consumption habits.

2005 **Campaign promoting solar water disinfection (SODIS) in Bolivia**
Design, implementation, and evaluation of interventions promoting SODIS.

TEACHING

Spring/Summer 2012

Gewohnheiten über die Lebensspanne (Habits across the lifespan)
Seminar, Department of Psychology, University of Constance

Verändern von gesundheitsrelevantem Alltagshandeln in Entwicklungsländern (Changing health-related everyday behaviors in developing countries)
Seminar, Department of Psychology, University of Constance

Praktische Intervention II: Veränderung von Alltagshandeln in der Entwicklungszusammenarbeit (Practical intervention II: Changing everyday behaviors in development cooperation)
Seminar, Department of Psychology, University of Zurich, in cooperation with Prof. Dr. H.-J. Mosler

2010 - 2011 Veränderung von Alltagshandeln (Changing everyday behaviors)
Seminar (annual), Department of Psychology, University of Zurich, assisting Prof. Dr. H.-J. Mosler

2008 - 2011 Project group „Veränderung von Alltagshandeln“ (Changing everyday behaviors)
Workshops (annual), Department of Psychology, University of Zurich, assisting Prof. Dr. H.-J. Mosler

MEMBERSHIPS

Deutsche Gesellschaft für Psychologie (DGPs)

European Health Psychology Society (EHPS)

Initiative Psychologie im Umweltschutz (IPU)

PUBLICATIONS

Peer-reviewed articles

Mosler, H.-J., Blöchliger, O. R., & Inauen, J. (2010). Personal, social, and situational factors influencing the consumption of drinking water from arsenic-safe deep tubewells in Bangladesh. *Journal of Environmental Management, 91*, 1316–1323.

Tobias, R. & Inauen, J. (2010). Gathering time-series data for evaluating behavior-change campaigns in developing countries: Reactivity of diaries and interviews. *Evaluation Review, 34,* 367–390.

In progress

Inauen, J., Hossain, M. M., Johnston, R. B., & Mosler, H.-J. (2012). *Acceptance and use of eight arsenic-safe drinking water options in Bangladesh.* Manuscript submitted for publication.

Inauen, J., Tobias, R., & Mosler, H.-J. (2012). *Predicting water consumption habits for seven arsenic-safe water options in Bangladesh.* Manuscript submitted for publication.

Inauen, J., & Mosler, H.-J. (2012). *Developing and testing theory-based and evidence-based interventions to promote switching to arsenic-safe wells in Bangladesh.* Manuscript submitted for publication.

Inauen, J., Tobias, R., & Mosler, H.-J. (2012). *Promoting safe water consumption by increasing commitment strength: A longitudinal mediation analysis.* Manuscript in preparation.

George, C. M., Inauen, J., Rahman, M. S., Zheng, Y. (2012). *Effectiveness of pay-for-use arsenic testing and community based education interventions in Bangladesh.* Manuscript submitted for publication.

Other publications

Mosler, H.-J., Huber, A., Inauen, J., & Tobias, R. (2012). How to achieve evidence-based behavioural change. *Sandec News, 13*, 14-15.

Huber, A., Inauen, J., & Mosler, H.-J. (2011). Increasing safe water consumption in Bangladesh and Ethiopia. *Sandec News, 12*, 6-7.

Inauen, J., & Gonzalez, A. (2009). „In den Köpfen der Menschen muss etwas verändert werden, damit Umweltprobleme gelöst werden können!“. Ein Interview mit einem Umweltpsychologen. *Forum der Geoökologie, 20*(2), 26-28.

Oral presentations

Inauen, J. (2012). *When and how a coping planning intervention affects safe water consumption: A moderated mediation analysis.* Oral presentation at the 26th Conference of the European Health Psychology Society (EHPS), Prague, Czech Republic.

Inauen, J., & Hossain, M. M. (2012). *Behavior change techniques to enhance arsenic-safe water consumption in Bangladesh.* Oral presentation at the 3rd International Conference on Research for Development (ICRD), Bern, Switzerland.

Inauen, J., & Mosler, H.-J. (2011). *Evidence-based promotion of arsenic-safe drinking water.* Oral presentation at the National Water and Sanitation Technology Sharing Workshop, Dhaka, Bangladesh.

Inauen, J., & Mosler, H.-J. (2011). *Developing behaviour change strategies to enhance arsenic-safe water consumption in Bangladesh.* Oral presentation at the 2nd International Water Association (IWA) Development Congress and Exhibition, Kuala Lumpur, Malaysia.

Inauen, J. (2011). *Developing theory-based public health interventions to enhance habitual arsenic-safe water consumption in Bangladesh.* Oral presentation at the 25th Conference of the European Health Psychology Society (EHPS), Crete, Greece.

Inauen, J., & Mosler, H.-J. (2010). *Risky consumption of drinking water: Predicting the use of arsenic-safe drinking water options in Bangladesh.* Oral presentation at the 27th International Congress of Applied Psychology, Melbourne, Australia.

Inauen, J., & Tobias, R. (2009). *Monitoring dynamic processes in environmental psychology. First applications of a method for collecting time-series data during behavior-change campaigns in Cuba and Bolivia.* Oral presentation at the 8th Biennial Conference on Environmental Psychology, Zurich, Switzerland.

Inauen, J., & Blöchliger, O. R. (2009). *Personal, social, and situational factors influencing acceptance and use of arsenic-free deep tubewells in Bangladesh.* Oral presentation at the 11th European Congress of Psychology, Oslo, Norway.

Poster presentations

Inauen, J., & Mosler, H.-J. (2010). *When drinking water is poisonous: Distal and proximal social-cognitive factors influencing habitual use of arsenic-safe water sources in Bangladesh.* Poster presented at the 24th Conference of the European Health Psychology Society (EHPS), Cluj-Napoca, Rumania.

Inauen, J., & Mosler, H.-J. (2010). *Environmental hazard: When drinking water is poisonous. Personal, social, and structural factors influencing the use of arsenic-safe deep tubewells in Bangladesh.* Poster presented at the 11th Swiss Global Change Day, Bern, Switzerland.

Inauen, J., & Mosler, H.-J. (2009). *Factors influencing consumption of safe drinking water: the example of arsenic-free deep tubewells in Bangladesh.* Poster presented at the 23rd Conference of the European Health Psychology Society, Pisa, Italy.